Appendix A
RFP & Addenda

CDM Smith

3715 Northside Parkway NW
Building 300, Suite 400
Atlanta, Georgia 30327
tel: 404 720-1400
fax: 404 467-4130

September 19, 2014

Mr. Paul Christy
Cambi, Inc.
5 Great Valley Parkway
Suite 250
Malvern, Pennsylvania 19355

Subject: Request for Proposal
City of Franklin, Tennessee
Franklin WRF Modifications & Expansion Project

Dear Mr. Christy:

The purpose of this letter is to outline CDM Smith's requirements for Cambi's proposal for the new thermal hydrolysis process (THP) that will be part of the City of Franklin Water Reclamation Facility (WRF) Modifications & Expansion Project (the Project).

Attached to this letter are preliminary biosolids drawings (Attachment A) and specifications relevant to the THP system (Attachment B). We are requesting proposals based on each of the following project phases:

- **Phase 1:** THP system to treat year 2025 maximum month biosolids loads as listed in Attachment C.
- **Phase 2:** Additional equipment required to be added to the THP system to treat year 2040 maximum month biosolids loads as listed in Attachment C.

For the purposes of our economic analysis, we would like to receive two proposals, one for each of the above listed phases. If additional equipment is not necessary to bring the THP system from Phase 1 to Phase 2, please state so in your response to this RFP.

Proposal packages should include the following information, submitted in searchable PDF format. In addition to the PDF submittal, please provide two hard copies of the proposal package in binders. The submittal shall be broken down into sections as outlined below:

- Section 1 – Bid Form (Attachment D)
- Section 2 – Detailed scope of supply

- Section 3 – Drawings of overall system layout, details of construction, and details of all major pieces of equipment within the THP's scope of supply.
- Section 4 – Electrical one line diagrams and process & instrumentation diagrams for the proposed system.
- Section 5 – Information on the PLC used to control the system, and how it will interconnect with the WRF SCADA system.
- Section 6 – Mass and energy balance sheets for each of the six operating scenarios listed in Attachment C. The balance sheet should include all flows within the THP System Supplier's scope, as well as mass and energy flows entering and exiting the THP's scope (steam, cooling water, dilution water, FOG, pre-dewatered cake, hydrolyzed sludge, and any other miscellaneous gas/fluid flows).
- Section 7 – O&M data, including:
  - Complete electrical load list for all pump and blower motors, control panels, instrumentation, etc.
  - Unit costs and annual replacement rates for all replaceable/consumable items (spare parts) including any applicable warranty structure.
  - Approximate labor requirements for replacement and servicing of components.
  - Provide annual operation and maintenance costs from an operating facility that utilizes the same system as being proposed for this project.
  - A description of the plan to provide operation and maintenance support to the Franklin system during the optimization and operator shadowing period, and after the contract has been completed.
- Section 8 - Provide a financial statement indicating the company's net worth (Assets-Liabilities) to prove the fiscal stability of the system supplier.
- Section 9 – Provide a list of installations, with contact information, for the same thermal hydrolysis technology being proposed herein. Also provide operating data from a facility that uses the technology proposed. The data should include:
  - Sludge influent and effluent characteristics (%DS, feed rate, ratio of primary and waste activated sludge in the feed solids)
  - Volatile Solids Destruction (VSD) in digesters

- Section 10 – A description of how the THP System Supplier will achieve certification as an equivalent Class A technology as defined by EPA Part 503 regulations. Include the estimated additional time and cost associated with this effort.
- Section 11 – Provide a quote for an optional one-year service contract. The service contract is intended to cover all operation and maintenance of the THP system, essentially a contract operation. The quote should detail the services the THP System Supplier intends to provide for this price.
- Section 12 – A complete list of exceptions, if any, to the specifications, addenda to this RFP, or the proposed terms of the pre-selection agreement below. If there are no exceptions, please state so in your response.

Proposal packages are due no later than 2 p.m. Eastern Time on October 6, 2014. Signed proposals in PDF format may be transmitted to us via e-mail or FTP site; all hard copy proposals should be forwarded to our Raleigh, North Carolina, office at the following address.

CDM Smith Inc.
5400 Glenwood Avenue, Suite 400
Raleigh, North Carolina 27612
Attn: Mr. Tom Nangle

We will issue any addenda to this RFP via e-mail; receipt of all addenda should be acknowledged in your proposals.

All proposals will be evaluated according to both present worth cost and non-cost criteria. The difference in O&M and capital costs incurred outside of the THP System Supplier's scope, as a result of the THP System Supplier's required inputs, will be taken into account. If Cambi is selected to provide the equipment for this project, we will notify you in writing no later than January 2, 2015.

The selected THP System Supplier will be named as the preselected supplier/equipment in the project specifications, and the THP system will be designed around the equipment defined in your Proposal. In return, within 30 days of the Notice to Proceed, you must agree to enter into an agreement with the contractor who is selected by the City to construct the Project, to provide the equipment and services as established in the Proposal. You must also agree to:

- Honor the equipment, materials and services costs as escalated per the Method of Cost Escalation for THP Equipment (Method), which is outlined in Attachment E.
- In the event that the bid opening date for the Project occurs later than the time period listed in the Method, agree to provide the equipment, materials and services at an adjusted selling price, calculated based on the Method.

- Agree to furnish replacement parts at a guaranteed price calculated based on the cost escalation method described in Section 11351, Paragraph 1.07C.
- Assist the General Contractor with functional testing, commissioning, and acceptance testing associated with the THP system as described in Attachment F.
- The City reserves the right to delete optional items from the scope of supply and deduct the cost of these optional items from the price without any penalty.
- If for any reason the City does not award the Project, the City is under no obligation to purchase the equipment, materials, and services in the Proposal.

We appreciate your interest in this important project. If you have any questions or comments on the attached information, please do not hesitate to contact me at (404) 720-1400.

Sincerely,

Carrie Carden, P.E., BCEE
Environmental Engineer
CDM Smith Inc.

Attachments

cc: David Parker, P.E., City of Franklin
Mark Hilty, P.E., City of Franklin
Bob Huguenard, P.E., BCEE, CDM Smith
Richard Tsang, Ph.D., P.E., BCEE, CDM Smith
Tom Nangle, CDM Smith

CDM Smith

3715 Northside Parkway NW
Building 300, Suite 400
Atlanta, Georgia 30327
tel: 404 720-1400
fax: 404 467-4130

September 19, 2014

Michele Kline
I. Kruger, Inc.
4001 Weston Parkway
Cary, North Carolina 27513

Subject: Request for Proposal
City of Franklin, Tennessee
Franklin WRF Modifications & Expansion Project

Dear Ms. Kline:

The purpose of this letter is to outline CDM Smith's requirements for Kruger's proposal for the new thermal hydrolysis process (THP) that will be part of the City of Franklin Water Reclamation Facility (WRF) Modifications & Expansion Project (the Project).

Attached to this letter are preliminary biosolids drawings (Attachment A) and specifications relevant to the THP system (Attachment B). We are requesting proposals based on each of the following project phases:

- **Phase 1:** THP system to treat year 2025 maximum month biosolids loads as listed in Attachment C.
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- Section 6 – Mass and energy balance sheets for each of the six operating scenarios listed in Attachment C. The balance sheet should include all flows within the THP System Supplier's scope, as well as mass and energy flows entering and exiting the THP's scope (steam, cooling water, dilution water, FOG, pre-dewatered cake, hydrolyzed sludge, and any other miscellaneous gas/fluid flows).
- Section 7 – O&M data, including:
  - Complete electrical load list for all pump and blower motors, control panels, instrumentation, etc.
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  - Provide annual operation and maintenance costs from an operating facility that utilizes the same system as being proposed for this project.
  - A description of the plan to provide operation and maintenance support to the Franklin system during the optimization and operator shadowing period, and after the contract has been completed.
- Section 8 - Provide a financial statement indicating the company's net worth (Assets-Liabilities) to prove the fiscal stability of the system supplier.
- Section 9 – Provide a list of installations, with contact information, for the same thermal hydrolysis technology being proposed herein. Also provide operating data from a facility that uses the technology proposed. The data should include:
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Proposal packages are due no later than 2 p.m. Eastern Time on October 6, 2014. Signed proposals in PDF format may be transmitted to us via e-mail or FTP site; all hard copy proposals should be forwarded to our Raleigh, North Carolina, office at the following address.

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All proposals will be evaluated according to both present worth cost and non-cost criteria. The difference in O&M and capital costs incurred outside of the THP System Supplier's scope, as a result of the THP System Supplier's required inputs, will be taken into account. If Kruger is selected to provide the equipment for this project, we will notify you in writing no later than January 2, 2015.

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Mark Hilty, P.E., City of Franklin
Bob Huguenard, P.E., BCEE, CDM Smith
Richard Tsang, Ph.D., P.E., BCEE, CDM Smith
Tom Nangle, CDM Smith

ATTACHMENT A
GENERAL SITE LAYOUT AND SCOPE OF SUPPLY

The following drawings are attached to this proposal for the THP System Supplier's reference.

- Preliminary Biosolids Handling Site Layout Plan
- Thermal Hydrolysis Manufacturer Scope of Supply Process Flow Diagrams

Please note that the site layout plan is not final, and therefore is subject to, and most likely will, change. Please also note that the process flow diagrams are intended to illustrate the boundary line between the THP System Supplier's scope of supply and the Contractor's scope of supply. The process flow diagrams are NOT intended to illustrate, or presume to define, all the components within the THP system, or the system configuration. The process flow diagrams estimate what each THP System Supplier intends to supply, based on preliminary conversations with the suppliers.

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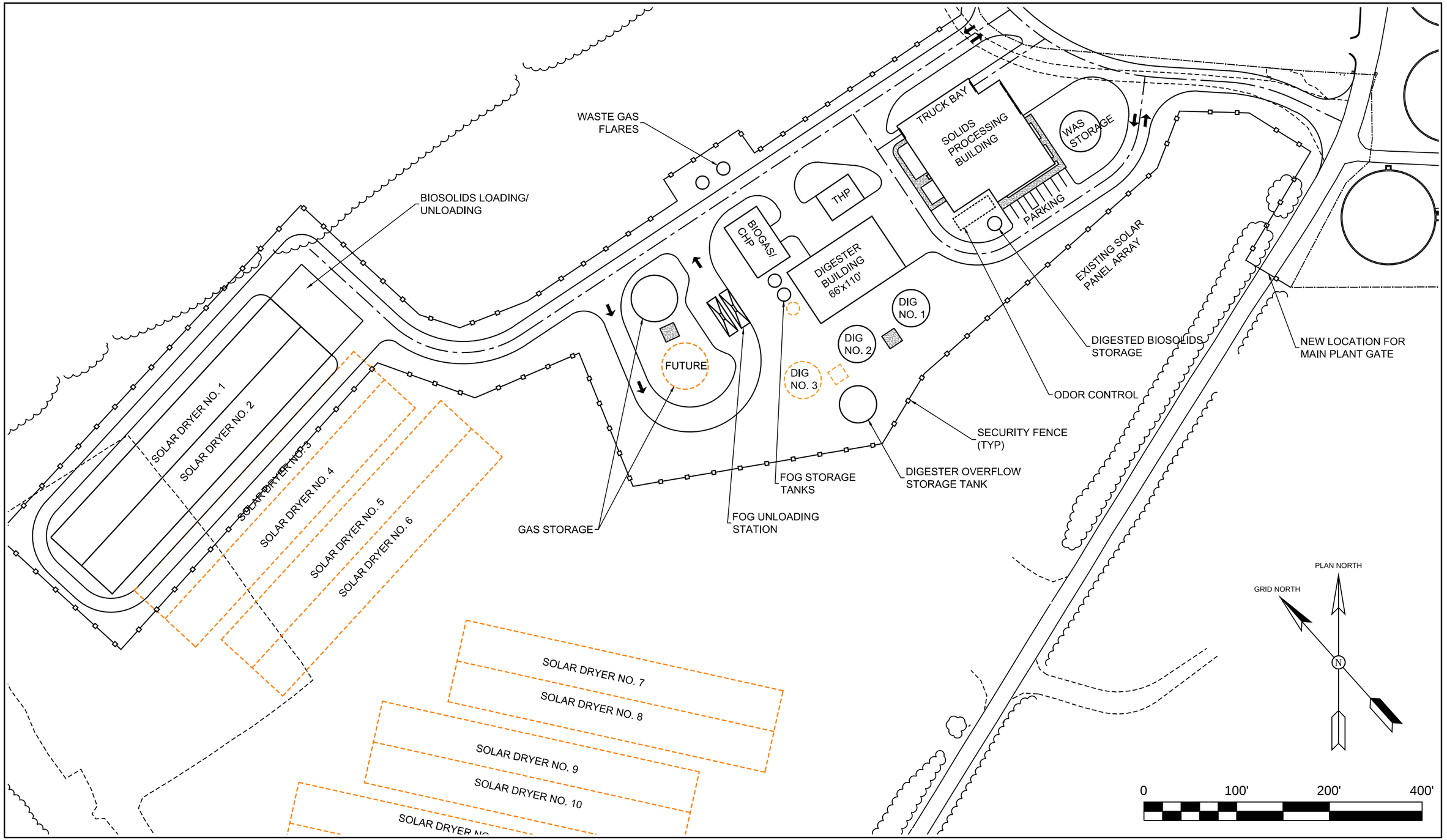

CDM Smith

Figure No. A-1
Franklin WRF
Preliminary Biosolids Site Schematic
September 2014

DWG: C:\pw_pl1\smithdr\d0108347\FIGURE A-2.dwg USER: smithdr
DATE: Jun 23, 2014 7:23am
©2014 CDM SMITH ALL RIGHTS RESERVED. REUSE OF DOCUMENTS: THESE DOCUMENTS AND DESIGNS PROVIDED BY PROFESSIONAL SERVICE, INCORPORATED HEREIN, ARE THE PROPERTY OF CDM SMITH AND ARE NOT TO BE USED, IN WHOLE OR PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CDM SMITH.
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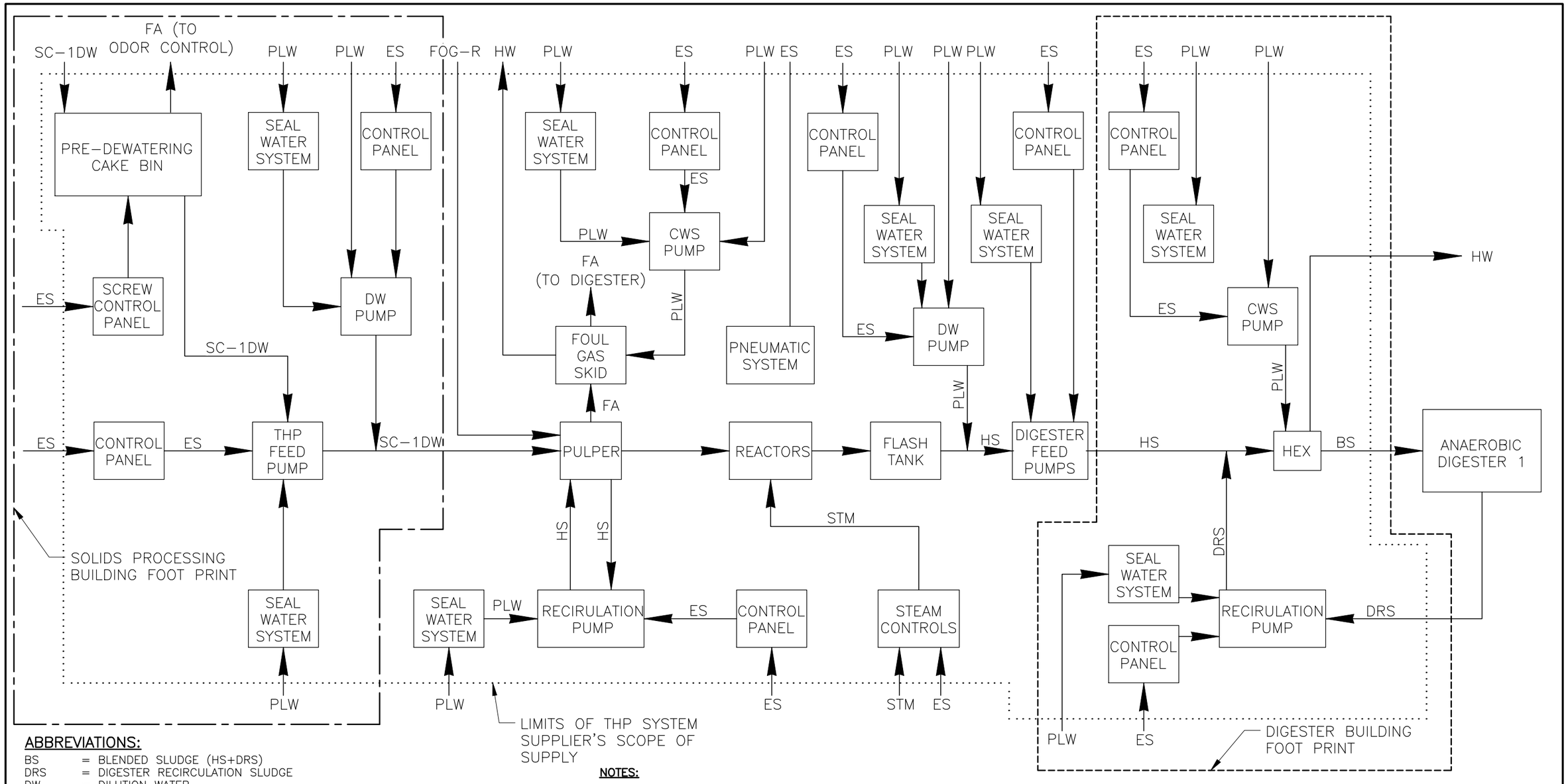

ABBREVIATIONS:

BS	=	BLENDED SLUDGE (HS+DRS)
DRS	=	DIGESTER RECIRCULATION SLUDGE
DW	=	DILUTION WATER
ES	=	ELECTRICAL SUPPLY
FA	=	FOUL AIR
FOG-P	=	FATS, OILS AND GREASE (PASTEURIZED)
FOG-R	=	FATS, OILS AND GREASE (RAW)
HS	=	HYDROLYZED SLUDGE (DIGESTER FEED SLUDGE)
HW	=	HOT WATER
PLW	=	PLANT REUSE WATER (CHLORINATED PLANT EFFLUENT)
SC-1DW	=	PRE-DEWATERING SLUDGE CAKE (TO THP)
STM	=	STEAM

NOTES:

1. THIS PROCESS FLOW DIAGRAM IS PROVIDED TO ILLUSTRATE THE LIMITS OF THE THP SYSTEM SUPPLIER'S SCOPE OF SUPPLY, AND IS NOT INTENDED TO BE A MANDATORY PROCESS FLOW THAT THE MANUFACTURER SHALL FOLLOW. THE PDF ILLUSTRATES THE ENGINEER'S UNDERSTANDING OF WHAT THE THP SYSTEM SUPPLIER PLANS TO SUPPLY, BASED ON THE PRELIMINARY CONVERSATIONS.

2. ALL EQUIPMENT WITHIN THE SCOPE OF SUPPLY THAT IS NOT LOCATED INSIDE OF THE SOLIDS PROCESSING BUILDING OR THE DIGESTER BUILDING SHALL BE LOCATED OUTSIDE ON THE THP CONCRETE PAD, AS SHOWN ON FIGURE NO. A-1.

CDM Smith

Figure No. A-2
Franklin WRF
CAMBI Scope of Supply
JUNE 2014

DWG: C:\pw_pl1\smithdr\d0108347\FIGURE A-3.dwg USER: smithdr
DATE: Jun 23, 2014 7:44am
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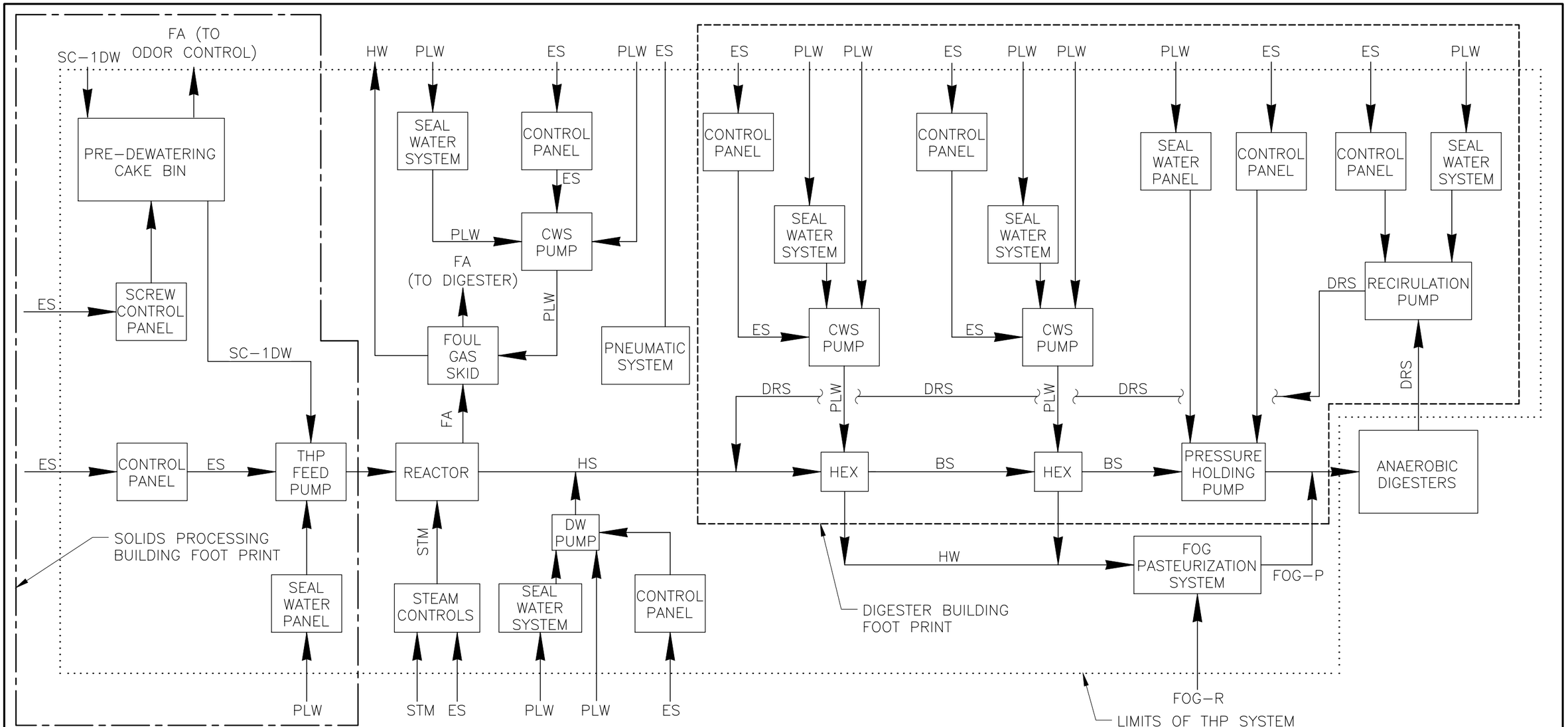
PL1\14915-96594\03R&S\09CADD FIGURES



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NOTES:

1. THIS PROCESS FLOW DIAGRAM IS PROVIDED TO ILLUSTRATE THE LIMITS OF THE THP SYSTEM SUPPLIER'S SCOPE OF SUPPLY, AND IS NOT INTENDED TO BE A MANDATORY PROCESS FLOW THAT THE MANUFACTURER SHALL FOLLOW. THE PDF ILLUSTRATES THE ENGINEER'S UNDERSTANDING OF WHAT THE THP SYSTEM SUPPLIER PLANS TO SUPPLY, BASED ON THE PRELIMINARY CONVERSATIONS.
2. ALL EQUIPMENT WITHIN THE SCOPE OF SUPPLY THAT IS NOT LOCATED INSIDE OF THE SOLIDS PROCESSING BUILDING OR THE DIGESTER BUILDING SHALL BE LOCATED OUTSIDE ON THE THP CONCRETE PAD, AS SHOWN ON FIGURE NO. A–1.

CDM Smith

Figure No. A-3
Franklin WRF
Kruger Scope of Supply
JUNE 2014

ATTACHMENT B
SPECIFICATIONS

The specifications that are relevant to the proposal for the pre-selection of the THP System Supplier are listed below and attached to this package.

Division 1 –

The Division 1 specifications listed are applicable to the THP System Supplier. The THP System Supplier shall take into account the costs associated with complying with the requirements set forth in these Division 1 specifications.

- 00610 Performance Bond
- 00615 Payment Bond
- 00700 Standard EJCDC General Conditions
- 00801 Supplemental Conditions (For THP Pre-Selection Only)
- 01025A Measurement and Payment (For THP Pre-Selection Only)
- 01100 Special Project Procedures
- 01300 Submittals
- 01322 Photographic Documentation
- 01445 Pipe Testing, Cleaning & Disinfection
- 01600 Delivery Storage and Handling
- 01664 Operation & Maintenance Training
- 01665 Equipment Testing & Startup
- 01730 Operation & Maintenance Data Submittals
- 01740 Warranties and Bonds

Division 9 –

The Division 9 specifications listed are designed to set a minimum standard for the proposed equipment. It is understood that the manufacturer will propose their standard equipment, as long as it meets the minimum requirements set forth in the below specifications.

- 09901 Surface Preparation and Shop Prime Painting
- 09902 Field Painting

Division 11 –

The Division 11 specifications listed are designed to set a minimum standard for the proposed equipment. It is understood that the manufacturer will propose their standard equipment, as long as it meets the minimum requirements set forth in the below specifications.

- 11000 General Requirements of Equipment
- 11002 Equipment Supports, Grouting, and Installation
- 11050 General Requirements for Centrifugal and Axial Flow Pumping Equipment
- 11243 Pre-Dewatered Sludge Storage Bins
- 11315A Progressing Cavity Pumps (For THP Pre-Selection Only)
- 11318 Sludge Recirculation Chopper Pumps
- 11351 Thermal Hydrolysis System
- 11373 Air Compressor System

Division 13 –

The Division 13 specifications listed are a reference for products and standards. Not everything in these specifications applies to the THP pre-selection package.

- 13300 I&C General Provisions
- 13311 PLC Hardware and Software
- 13320 Control and Data Network Equipment
- 13321 Fiber Optic Cabling and Equipment
- 13330 Control Panel Enclosures and Panel Equipment
- 13340 I&C Instruments

Division 15 –

The Division 15 specifications listed are designed to set a minimum standard for the proposed equipment. It is understood that the manufacturer will propose their standard equipment, as long as it meets the minimum requirements set forth in the below specifications.

- 15051 Piping General Requirements
- 15061 Steel Pipe and Fittings
- 15063 Copper Pipe and Fittings
- 15064 Plastic Pipe and Fittings
- 15066 Stainless Steel Pipe and Fittings
- 15072 Ductile Iron Pipe and Fittings
- 15100 Valves
- 15120 Piping Specialties
- 15140 Pipe Hangers, Supports & Restraints
- 15250 Thermal Insulation for Process Equipment & Piping
- 15257 Electrical Heat Tracing
- 15754 Heat Exchangers

Division 16 –

The Division 16 specifications listed are a reference for products and standards. Not everything in these specifications applies to the THP pre-selection package.

- 16000 Electrical General Provisions
- 16110 Raceways, Boxes, Fittings and Supports
- 16120 Wires and Cables
- 16150 Motors
- 16191A Miscellaneous Equipment (For THP Pre-Selection Only)
- 16370 Variable Frequency Drives
- 16500 Lighting System

ATTACHMENT C
DESIGN CRITERIA AND PHASING

Phasing

The upgrades to the biosolids facilities at the City of Franklin Water Reclamation Facility (WRF) will be constructed in two phases. The first phase of upgrades will be completed in 2018 and will be designed to treat year 2025 biosolids loads (Phase 1). An expansion will be constructed in the future to expand the capacity to treat year 2040 biosolids loads (Phase 2).

This proposal requires the THP System Supplier to design for Phase 1 maximum month loads, with the ability to expand to Phase 2 maximum month loads. In order to evaluate the life cycle costs of each proposal, the THP System Supplier is required to provide detailed operational information for initial startup loads, Phase 1 design loads, and Phase 2 design loads. Mass & energy flow sheets must be provided in Section 6 of the proposal for each loading scenario. The operational information for the initial loading scenario is needed to properly capture the operational costs for loading during the time period from 2018 to 2025.

Pre-Dewatered WAS Characteristics for Each Loading Scenario

Waste activated sludge (WAS) will be pumped to the biosolids facilities and pass through sludge screens before entering the WAS Storage Tank. The WAS will then be pre-dewatered via centrifuges (to within 3 percent of the percent dry solids cake that is listed in the winning bidder's proposal) and conveyed into the pre-dewatered sludge storage bin (start of THP System Supplier's scope).

Table 1 lists the estimated pounds of waste activated sludge per day (expressed in terms of dry solids) that will enter the pre-dewatered sludge storage bin for each of the loading scenarios. Since the two THP System Suppliers prefer different percent cake solids, each manufacturer will have to calculate the volumetric flow rate, based on their percent cake solids, as illustrated by the equation in the table.

TABLE 1: Pre-Dewatered WAS Characteristics

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	20,173	26,225	26,897	34,966	43,035	55,946
TS (%)[1]	Require % dry solids into sludge hopper is a bid item in the proposal.					
Flow Rate (gal/day)	Flow rate is a function of the TS% (Flow Rate = TS / %TS / 8.34lbs per gal.					
VS as % of TS (%)[2]	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%
VS (lb/day)	13,112	17,046	17,483	22,728	27,973	36,365

[1] Due to the limited dewaterability of WAS, the maximum % solids cake that can be provided is 22%.

[2] The expected volatile solids (VS) average is 65% of the total solids; however the Supplier should expect to see a range between 60-70% VS.

FOG Characteristics for Each Loading Scenario

Fats, oils and grease (FOG) will be delivered to the biosolids facility, where it will be heated, screened, macerated via chopper pumps, and conveyed, through insulated and heat traced pipe, to the destination specified by the winner of the pre-selection bid.

Table 2 lists the projected pounds per day (expressed in terms of dry solids) of FOG to be delivered to the biosolids facility for each loading scenario. Since the two THP System Suppliers prefer different injection locations, each manufacturer will have to apply this information into their models at the appropriate injection point.

TABLE 2: FOG Characteristics

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	667	1,001	801	1,201	1,168	1,768
TS (%)[1]	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
Flow Rate (gal/day)	2,000	3,000	2,400	3,600	3,500	5,300
VS as % of TS (%)[2]	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
VS (lb/day)	567	851	681	1,021	993	1,503

[1] The expected total solids (TS) average is 4%; however the Supplier should expect to see a range between 4-10% TS.

[2] The expected volatile solids (VS) average is 85% of the total solids; however the Supplier should expect to see a range between 80-90% VS.

ATTACHMENT D
Bid Forms

Bid Items

This attachment includes bid item tables that ask for additional information that will be used to evaluate the proposals. The bid items are organized into one of the following four categories: Cost Items, Data Items, Operational Items, and Performance Guarantee Items.

Cost Items:

Table 1's "Cost Bid Items" are used to determine the phase 1 and phase 2 capital cost of the THP system. If additional equipment is not necessary to bring the THP system from phase 1 to phase 2, please insert a zero dollar value in the "Phase 2 Budget Cost" column for Table 1. The table will also serve as a schedule of values that will be used to determine payment associated with completed milestones. The THP System Supplier should review Appendix B of this package, for details on what is required for each equipment item below, and how progress will be measured and paid for; specific attention should be given to:

1. Specification 11351 – Thermal Hydrolysis System
2. Individual equipment specifications referenced in Specification 11351
3. Specification 01025A – Measurement and Payment (For THP Pre-Selection Only)

In addition to capital costs, the THP System Supplier shall input a price for the following miscellaneous cost items:

14. A Performance Warranty bond
    a. As described in specification 01025A and 11351.
    b. This bond is separate from the typical equipment warranty outlined in the individual equipment specifications. The price of the standard equipment warranty shall be included in the cost items for the individual pieces of equipment.
15. The costs associated with achieving certification as an equivalent Class A technology
    a. A description of the process the THP system supplier will use to achieve the certification should be provided in Section 10 of your proposal.
16. Optimization and Operator Shadowing
    a. Upon completion of the acceptance testing, the THP System Supplier's Representative shall operate and optimize the THP system for 60 days. During this time plant operators will shadow the representatives. Franklin WRF is manned 24 hours a day, 7 days a week (24/7); the THP System Supplier shall provide on-site personnel 24/7 during this 60 day period to allow plant staff on all 3 shifts ample time for shadowing. The System Supplier should budget to have multiple operation personnel at Franklin during these 60 days to be able to provide 24/7 on site operation.
    b. As described in paragraphs 1.05 and 1.11 in specification 11351.
17. An optional one year service contract
    a. The service contract is intended to cover all operation and maintenance of the THP system, essentially a contract operation. A quote detailing the services the THP System Supplier intends to provide for this price shall be provided in Section 11 of your proposal.

Data Items:

Table 2's "Data Bid Items" are used to evaluate the THP System Suppliers based on "non-cost" items. The four non-cost items that are being evaluated are:

1. Total number of worldwide installations of the same model being proposed for the City of Franklin.
    a. An Installation list should be provided in Section 9 of your proposal, along with operating data of a plant using the same technology as is being proposed for this project.
2. Number of years the model has been manufactured.
3. Number of operation and maintenance support staff available, and their location.
    a. The number of operation and maintenance staff currently available to travel to the Franklin WRF to work on the system.
    b. The city in which the home office of the support staff is located.
    c. In Section 7Provide a description of the plan to provide operation and maintenance support to the Franklin system after the contract has been completed.

4. Financial Stability of the THP System Supplier.
    a. A financial statement of the THP System Supplier should be provided in Section 8 of your proposal.
    b. No information is required to be entered into the table below, but the information provided to satisfy item 4.b will be taken into account during the evaluation.

Operational Items:

Table 3's "Operational Bid Items" are used to evaluate the Operational costs associated with the system offered under your proposal. Values for each of the operational bid items described below shall be provided for each of the six loading scenarios described in Attachment C.

1. Total Motor HP of system.
    a. This is the total HP for all operating equipment in the system for each of the six scenarios (i.e., not the total horsepower of all the motors, but the total horsepower for all operating motors, excluding the standby horsepower). This number should be supported by the information provided in Section 7 of your proposal.
2. Required Percent Dry Solids.
    a. The THP System Supplier's required percent (%) dry solids concentration for sludge being conveyed into the THP System Supplier's system (pre-dewatered sludge storage bin).
        i. It is not practical to produce a cake that consistently meets the exact percent solids required. Instead, a range of cake solids will be provided; the range will be between 0-3% greater than the number specified by the THP System Supplier. The THP System Supplier is expected to supply a dilution system to maintain the % solids required into their reactor(s).
        ii. Due to the limited dewaterability of waste activated sludge (WAS), the maximum cake solids that pre-dewatering can provide to the THP system is 22%.
    b. These values should match what is shown on the Mass & Energy Flow Sheets submitted in Section 6 of your proposal.

3. Total Plant Re-Use Water Demand for the system offered under your proposal.
    a. Total plant re-use water demands include:
        i. Dilution water demands
        ii. Seal water demands
        iii. Cooling water demands for heat exchangers.
    b. Plant effluent water temperatures and contaminant concentrations to be used in THP System Supplier's mass & energy diagrams are listed in paragraph 1.06 in Specification 11351.
    c. The values entered in the table should match what is shown on the Mass & Energy Flow Sheets submitted in Section 6 of your proposal.

Performance Guarantee Items:

There are a total of 4 performance guarantees that apply to the THP System Supplier:

1. Achievement of Class A Biosolids
2. Hydrolyzed Sludge Cooling System
3. Percent Volatile Solids Destruction (%VSD)
4. THP System Steam Usage

Performance guarantees 1 and 2 are predefined; performance guarantees 3 and 4 will be defined by the THP System Supplier in their bid package. Table 4's "Performance Guarantee Bid Items" are used to set the values for performance guarantees 3 and 4, as well as to evaluate operational costs associated with the proposed system. Values for each of the performance guarantee bid items described below shall be provided for each of the six loading scenarios described in Attachment C. For more information on performance guarantees, see Attachment F of this package.

The performance guarantee items described below are similar to the operational items above except liquidated damages will be assessed to the THP supplier for not meeting the proposed performance guarantees. The liquidated damages are described in Specification 11351.

3. Percent Volatile Solids Destruction (%VSD)
    a. Please propose a guaranteed %VSD as a function of the THP systems loading of hydrolyzed sludge to the anaerobic digesters.
    b. The anaerobic digesters will be:
        i. Operated in the mesophilic temperature range.
        ii. 40 foot diameter with a 40 foot side water depth and a flat bottom.
        iii. Mixed with either recirculation pumps or draft tube mixers.
        iv. Operate at a minimum 15 day solids retention time (SRT) and 12 day SRT at annual average day flows and maximum month flows, respectively.
    c. Due to the significant variations in FOG characteristics that can be experienced from shipment to shipment, during startup and performance testing, only WAS will be fed to the THP system and the anaerobic digesters. The THP System Supplier shall estimate the %VSD in the anaerobic digesters based on WAS flows only.
4. Saturated Steam demand for the scenarios described in Attachment C.
    a. The saturated steam pressure and flow rate requirements to heat and pressurize the mass flow of dry solids for each loading scenario described in Attachment C.

ATTACHMENT D – Bid Forms

Table 1: Cost Bid Items

Bid Item #	Description	Specification 11351 Paragraph #	Phase 1 Budget Cost (US Dollars)	Phase 2 Budget Cost (US Dollars)
1	Pre-Dewatered Sludge Storage Bin	1.03 & 2.02	$	$
2	Progressing Cavity Pumps	1.03 & 2.03	$	$
3	Water Service Pumps	1.03 & 2.04	$	$
4	Pressure Vessel(s)	1.03 & 2.05	$	$
5	Valves and Actuators	1.03 & 2.06	$	$
6	Piping Systems	1.03 & 2.07	$	$
7	Heat Tracing, Insulation and Cladding	1.03 & 2.08	$	$
8	Air Compressor System	1.03 & 2.09	$	$
9	Heat Exchangers	1.03 & 2.10	$	$
10	Chopper Pumps	1.03 & 2.11	$	$
11	Variable Frequency Drives	1.03 & 2.12	$	$
12	Instrumentation and Controls	1.03 & 2.13	$	$
13	Electrical	1.03 & 2.14	$	$
14	Other Equipment, Materials and Associated Services Not Included In Bid Items 1 Through 13		$	$
15	Warranty Bond for the THP System	1.08 and 3.08	$	$
16	Cost to Achieve Certification as Equivalent Class A Technology	1.06.I	$	$
17	Optimization and Operator Shadowing	1.05 & 1.11	$	$
18	Optional one (1) Year-Service Contract	-	$	$
19	Payment and Performance Bonds		$	$

ATTACHMENT D – Bid Forms

Table 2: Data Bid Items

Bid Item Description		Bid	
Data Item 1	Number of Installations		
Data Item 2	Years Model has been Manufactured		
Data Item 3	Number of staff / Location of Staff		

Table 3: Operational Bid Items

Bid Item Description		Initial Startup Load, Year 2018		Phase 1 Design Load, Year 2025		Phase 2 Design Load, Year 2040	
		Average Day	Max. Month	Average Day	Max. Month	Average Day	Max. Month
Operational Item 1	HP						
Operational Item 2	% DS						
Operational Item 3	gpm						

Table 4: Performance Guarantee Bid Items

Bid Item Description		Initial Startup Load, Year 2018		Phase 1 Design Load, Year 2025		Phase 2 Design Load, Year 2040	
		Average Day	Max. Month	Average Day	Max. Month	Average Day	Max. Month
Performance Guarantee 3	%VSD						
Performance Guarantee 4	lb/hr & psi						

ATTACHMENT E
METHOD OF COST ESCALATION

The Method will become an attachment to the Letter of Intent signed by the Owner and the selected THP System Supplier. The selected THP System Supplier will be expected to agree to provide the equipment, materials and services at an adjusted selling price calculated based on this Method.

1. The Base Selling Price of the Franklin WRF THP equipment is set at $_____. This price includes the following items listed in the Proposal:

    a. THP System ($_____)
    b. 1 Year Service Contract ($_____)

    This Base Selling Price is valid as of October 6, 2014, hereafter referred to as the Due Date for THP Proposals.

2. The Base Selling Price shall be adjusted in accordance with the percent change in the Producer Price Index (PPI) for Capital Equipment, not seasonally adjusted, as appears in the monthly *PPI Detailed Report* published by the Bureau of Labor Statistics (http://www.bls.gov/ppi/ppi_dr.htm).

    In the event that the PPI for Capital Equipment is unavailable for either or both of the time periods used in the adjustment of the Base Selling Price, the PPI for Finished Goods Less Foods and Energy, not seasonally adjusted, shall be used in its place.

3. The Adjusted Selling Price shall be calculated according to the following formula:

    Adjusted Selling Price =
    Base Selling Price x (PPI as of Date of Advertisement for Bids / PPI as of Due Date for THP Proposals)

    Where

    - Base Selling Price is as listed in Paragraph 1 above.

    - PPI as of Date of Advertisement for Bids = PPI for Capital Equipment, not seasonally adjusted, available on the first Date of Advertisement for Bids. The PPI used shall be for the most recent month for which data are available and shall be the first-published version.

    - PPI as of Due Date for THP Proposals = Latest version of the PPI for Capital Equipment, not seasonally adjusted, available for the calendar month in which the Due Date for THP Proposals falls. The latest version of the PPI shall incorporate revisions or corrections made by BLS prior to the first Date of Advertisement for Bids.

4. The THP System Supplier shall honor the Adjusted Selling Price for a period of two years from the Due Date for THP Proposals.

ATTACHMENT F

Introduction

The thermal hydrolysis specification refers the Contractor to Appendix XX to the Contract for information on functional testing, commissioning and acceptance testing. That Appendix is still being created, and is not available for this pre-selection RFP. For the purposes of this pre-selection bid, this attachment will cover all of the functional testing, commissioning and acceptance testing requirements that are relevant to the THP System Supplier. The Contractor shall be responsible for the coordination of all testing and startup, but the Contractor will require the equipment manufacturers to assist and/or operate their equipment/systems during the testing.

The purpose of the Functional Testing, Commissioning and Acceptance Testing is to demonstrate that the Project meets all performance requirements set forth in the Contract.

- Functional testing is to confirm the system's readiness to initiate operation with process fluids.
- Commissioning is the startup of the system with process fluids to establish stable operation and demonstrate qualitative compliance with process objectives.
- Acceptance testing is to confirm compliance with Performance Guarantee requirements.

This attachment sets forth supplementary requirements and information concerning Functional Testing, Commissioning and Acceptance Testing as it is relevant to the thermal hydrolysis process.

Functional Testing

Prior to initiating any Functional Testing or Commissioning activities with respect to the THP system, the Contractor shall complete:

1. All fabrication, assembly and installation for piping, wiring and equipment within the system;
2. All quality control testing and inspections for piping, wiring and equipment within the system; and
3. The Operation & Maintenance Manuals associated with the system in accordance with Specification 01730. The Contractor also must meet additional pre-test requirements that are not listed here.

In general the functional testing uses water to confirm the readiness to initiate commissioning activities with process fluids. The below list outlines functional testing associated for the THP system.

- Confirm functionality of foul air system
- Observe operation of all motor driven, rotating equipment components. Confirm responsiveness of motor driven equipment and motor operated valves to local and remote controls. Confirm variable speed equipment and modulating valves operate over the full design range.
- Observe qualitative response of installed instrumentation (i.e. sensors for level, pressure, flow, and temperature) to changes in process variables.
- Confirm hydraulic integrity under dynamic conditions for liquid bearing components, including tanks, pumps, valves, pipes and fittings with interconnecting joints.

- Measure flow and head for pumping equipment for no less than three points on the performance curve using water. Compare measured pump flow and pressure with submittal curves and design values after adjusting for differences in fluid characteristics and operating conditions.
- Confirm ability to deliver process steam to THP reactor vessel(s) to raise water to selected temperature and pressure.
- Confirm ability to circulate cooling water through digester heat exchangers at maximum design flow rate.
- Perform Functional Testing on all life-safety systems, including fire alarms, normal lighting, emergency lighting, eye wash showers, and sump pumps. Measure flow and pressure balance of HVAC supply air handling units, exhaust fans, and ductwork system to confirm capability to maintain ventilation air flow to all occupied spaces. Compare measured fan flow and pressure with submittal curves and design values after adjusting for differences in operating conditions. System balancing shall be performed for each ventilation system. Systems for air conditioning and heating shall be tested to confirm ability to maintain temperatures within established set-points. Functional Testing of life-safety systems for a building shall be completed prior to initiating Commissioning of other systems in that building.

If, in the opinion of the Engineer and Owner, the system meets the requirements specified herein, the system will advance to Commissioning. If, in the opinion of the Engineer and Owner, the functional tests do not meet the requirements specified herein, commissioning will not begin until the Contractor, with the help of the THP System Supplier where applicable, has made, at no cost to the Owner, such adjustments, changes, and/or additions as necessary to correct the system and demonstrated this by a satisfactory functional test as specified above.

Commissioning

In addition to the pretest requirements listed in the Functional Testing section, the Contractor must complete Functional Testing and Witness Combined Loop Test activities associated with a system or subsystem before initiating Commissioning. The Witness Combined Loop Test is a test performed on each control loop interfacing with the process control system.

In general, the commissioning relevant to the THP system is listed below:

- Initiate operation of process systems with introduction of design base fluids.
- Continue operation with progressively higher loading rates until the process approaches design capacity or accommodates all available input fluid, whichever occurs first.
- Tune and adjust process system to achieve stable operation with consistent production of design objective.
- Commissioning activities requiring operation of the digester feed pumps and solids dilution system cannot be initiated until some Hydrolyzed Solids can be forwarded to the digesters.
- Conditions for demonstration of stable operation must include the following items:
    - Measurable mass reduction in total suspended solids (TSS).
    - Consistent reaction time at target pressure/temperature in all reaction vessels OR Consistent target pressure/temperature at varying flow-rates within the THP reactor.
    - Maintaining equal flow to multiple on-line digester heat exchangers.

- Maintaining minimum short term (< 2 hours) temperature variation in the Hydrolyzed Solids feed to the digester heat exchangers.

Acceptance Testing

Prior to initiating Acceptance Testing activities, the Contractor must complete the following activities associated with a system.

- Achieve stable operation in an acceptable performance range confirmed by analysis of data from on-line instruments monitored by PCS.
- Complete O&M training sessions for equipment and subsystem components of the system in accordance with Specification 01730.
- Ensure that all loops have been commissioned and are tuned with process fluids. The tuning that is completed under the Functional Testing period shall be checked and adjusted after actual process fluids are being used. This means that wastewater solids, digester gas, steam, foul gas streams, and other process fluids are moving through the system at flow-rates and concentrations that are typical of full-scale operation.
- Demonstrate that PCS is shown to be recording accurate data consistent with field information and consistent with analytical data or other supporting information. The subsequent Acceptance Testing may utilize PCS data along with separate and independent field-collected or separately collected information. If there are discrepancies between data shown in the PCS and separately collected information, Contractor needs to reconcile those discrepancies.

Acceptance testing involves wet testing of the systems and subsystems using process fluids to confirm compliance with the Performance Guarantees. The performance guarantees that are relevant to the THP system are described below.

Performance Guarantees

Class A Biosolids

The THP System Supplier shall achieve certification as a Class A equivalent technology as defined by EPA Part 503 regulations within 2 years of commissioning of the biosolids system. The THP System Supplier is responsible for all of the costs and effort associated with achieving this certification; these efforts include, but are not limited to,

- Coordinating with the appropriate EPA and TDEC officials,
- Hiring an approved laboratory to complete tests on all analytical samples, and
- Coordinating with the General Contractor.

Hydrolyzed Sludge Cooling System

This Performance Guarantee shall demonstrate that the digester cooling system is capable of maintaining digester temperature within +/-2°F of 100 °F under all conditions. These conditions include the digester feed rate, temperature of plant reuse water, and ambient air temperatures. The design ambient air temperature shall be 16 °F minimum and 94 °F maximum. The design plant reuse water (the cooling water supply) shall be 54 °F minimum and 81°F maximum. The maximum ambient air temperature shall be considered to be coincident with maximum plant reuse water temperature and 6 mph wind speeds, and the minimum ambient air temperature shall be considered to be coincident with

minimum plant reuse water temperature and 9 mph wind speeds. The test duration shall be a minimum of 30 days.

If it is not possible to demonstrate operation under the full cooling water design temperature range, documentation and calculations shall be provided to verify the capacity of the cooling heat exchangers under the full temperature range. Documentation and calculations will be subject to City of Franklin WRF's approval. Measurements of the solids and cooling water shall be collected during testing, including temperature, flow rate, total solids content by weight, and pressure. All measurements shall be continuous except for solids content by weight. The test duration shall be a minimum of two days (48 hours) and the test media (solids side) shall be mixed solids containing Hydrolyzed Solids at initial startup feed conditions (__ pounds per day) and Digested Solids.

Comment [TJN1]: To be taken from winning THP System Supplier's proposal.

The Contractor shall also demonstrate the stability of the cooling system at turn down to the cooling water flows for minimum heat removal conditions at the coldest cooling water design temperature of 54°F. If it is not possible to demonstrate operation with the cooling water at 54°F, documentation and calculations shall be provided to determine the cooling water flow rate at this condition and the cooling system shall be shown to operate stably at this flow rate. Documentation and calculations will be subject to City of Franklin WRF's approval.

Percent Volatile Solids Destruction (%VSD)

This Performance Guarantee requires that the Contractor show that the percent volatile solids destruction achieved in the digesters for the varying operating scenarios meets the values listed in the table below.

Percent Volatile Solids Reduction	Initial Startup Flows, Year 2018		Phase 1 Flows, Year 2025		Phase 2 Flows, Year 2040	
	Avg Day	Max Month	Avg Day	Max Month	Avg Day	Max Month
% VSR						

Comment [TJN2]: These numbers will be taken from the winning bidder's proposal.

The anaerobic digesters will be:

- Operated in the mesophilic temperature range.
- 40 foot diameter with a 40 foot side water depth and a flat bottom.
- Mixed with either recirculation pumps or draft tube mixers.
- Operated at a minimum 15 day solids retention time (SRT) and 12 day SRT at annual average day flows and maximum month flows, respectively.

Due to the nature of FOG shipments to have unpredictable characteristics, during startup and performance testing, only waste activated sludge will be fed to the THP system and the anaerobic digesters. The THP System Supplier shall estimate the %VSD in the anaerobic digesters based on WAS flows only.

Steam Usage

This Performance Guarantee requires that the Contractor show that steam usage per ton of dry solids throughput, required to heat and pressurize the THP system as specified, will not exceed __ tons of steam per ton of dry solids feedstock to THP for 24 hours. The feed solids to the THP must be at least __ percent solids (average) and the range of THP input cake solids must be within the range of __ to __ percent solids.

Comment [TJN3]: To be taken from winning manufacturer's proposal.

Comment [TJN4]: To be taken from winning manufacturer's proposal.

Comment [TJN5]: To be taken from winning manufacturer's proposal.

PERFORMANCE BOND
FOR PROCUREMENT CONTRACTS

Any singular reference to Seller, Surety, Buyer, or other party shall be considered plural where applicable.

SELLER (Name and Address):

SURETY (Name and Address of Principal Place of Business):

BUYER (Name and Address):

CONTRACT
Date:
Amount:
Description (Name and Location):

BOND
Date (Not earlier than Contract Date):
Bond Number:
Amount:
Modifications to this Bond Form:

Surety and Seller, intending to be legally bound hereby, subject to the terms set forth below, do each cause this Performance Bond to be duly executed on its behalf by its authorized officer, agent, or representative.

Seller as Principal
Company: (Corp. Seal)

Signature:
Name and Title:

Surety
Company: (Corp. Seal)

Signature:
Name and Title:
(Attach Power of Attorney)
Address:

Telephone Number:

(Space is provided below for signatures of additional parties, if required.)

Seller as Principal
Company: (Corp. Seal)

Signature:
Name and Title:

Surety
Company: (Corp. Seal)

Signature:
Name and Title:
Address:
Telephone Number:

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1. Seller and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns to Buyer for the performance of the Contract, which is incorporated herein by reference. For purposes of this bond, Buyer means Buyer's assigns, if and when Buyer has assigned the Contract.

2. If Seller performs the Contract, Surety and Seller have no obligation under this Bond, except to participate in conferences as provided in Paragraph 3.1.

3. If there is no Buyer Default, Surety's obligation under this Bond shall arise after:

   3.1. Buyer has notified Seller and Surety pursuant to Paragraph 10 that Buyer is considering declaring a Seller Default and has requested and attempted to arrange a conference with Seller and Surety to be held not later than 15 days after receipt of such notice to discuss methods of performing the Contract. (If Buyer, Seller, and Surety agree, Seller shall be allowed a reasonable time to perform the Contract, but such an agreement shall not waive Buyer's right, if any, subsequently to declare a Seller Default); and

   3.2. Buyer has declared a Seller Default and formally terminated Seller's right to complete the Contract. Such Seller Default shall not be declared earlier than 20 days after Seller and Surety have received notice as provided in Paragraph 3.1; and

   3.3. Buyer has agreed to pay the Balance of the Contract Price to:

      a. Surety in accordance with the terms of the Contract;

      b. Another seller selected pursuant to Paragraph 4.3 to perform the Contract.

4. When Buyer has satisfied the conditions of Paragraph 3, Surety shall promptly and at Surety's expense take one of the following actions:

   4.1. Arrange for Seller, with consent of Buyer, to perform and complete the Contract; or

   4.2. Undertake to perform and complete the Contract itself, through its agents or through independent contractors; or

   4.3. Obtain bids or negotiated proposals from qualified sellers acceptable to Buyer for a contract for performance and completion of the Contract, arrange for a contract to be prepared for execution by Buyer and a seller selected with Buyer's concurrence, to be secured with performance and payment bonds executed by a qualified surety equivalent to the Bonds issued on the Contract, and pay to Buyer the amount of damages as described in Paragraph 6 in excess of the Balance of the Contract Price incurred by Buyer resulting from Seller Default; or

   4.4. Waive its right to perform and complete, arrange for completion, or obtain a new seller, and with reasonable promptness under the circumstances, either:

      a. determine the amount for which it may be liable to Buyer and, as soon as practicable after the amount is determined, tender payment therefor to Buyer; or

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b. deny liability in whole or in part and notify Buyer citing reasons therefor.

5. If Surety does not proceed as provided in Paragraph 4 with reasonable promptness, Surety shall be deemed to be in default on this Bond 15 days after receipt of an additional written notice from Buyer to Surety demanding that Surety perform its obligations under this Bond, and Buyer shall be entitled to enforce any remedy available to Buyer. If Surety proceeds as provided in paragraph 4.4, and Buyer refuses the payment tendered or Surety has denied liability, in whole or in part, without further notice Buyer shall be entitled to enforce any remedy available to Buyer.

6. After Buyer has terminated Seller's right to complete the Contract, and if Surety elects to act under Paragraph 4.1, 4.2, or 4.3, then the responsibilities of Surety to Buyer shall not be greater than those of Seller under the Contract, and the responsibilities of Buyer to Surety shall not be greater than those of Buyer under the Contract. To a limit of the amount of this Bond, but subject to commitment by Buyer of the Balance of the Contract Price to mitigation of costs and damages on the Contract, Surety is obligated without duplication for:

   6.1. the responsibilities of Seller for correction or replacement of defective Goods and Special Services and completion of the Contract;

   6.2. Additional legal, design professional, and delay costs resulting from Seller's Default, and resulting from the actions of or failure to act of Surety under Paragraph 4; and

   6.3. Liquidated damages, or if no liquidated damages are specified in the Contract, actual damages caused by delayed performance or non-performance of Seller.

7. Surety shall not be liable to Buyer or others for obligations of Seller that are unrelated to the Contract, and the Balance of the Contract Price shall not be reduced or set off on account of any such unrelated obligations. No right of action shall accrue on this Bond to any person or entity other than Buyer or its heirs, executors, administrators, successors, or assigns.

8. Surety hereby waives notice of any change, including changes of time, to the Contract or to related subcontracts, purchase orders and other obligations.

9. Any proceeding, legal or equitable, under this Bond may be instituted in any court of competent jurisdiction in the location of the Point of Destination, and shall be instituted within two years after Seller Default or within two years after Seller ceased working or within two years after Surety refuses or fails to perform its obligations under this Bond, whichever occurs first. If the provisions of this paragraph are void or prohibited by law, the minimum period of limitation available to sureties as a defense in the jurisdiction of the suit shall be applicable.

10. Notice to Surety, Buyer or Seller shall be mailed or delivered to the address shown on the signature page.

11. When this Bond has been furnished to comply with a statutory or other legal requirement in the location of the Point of Destination, any provision in this Bond conflicting with said statutory or legal requirement shall be deemed deleted herefrom and provisions conforming to such statutory or other legal requirement shall be deemed incorporated herein. The intent is that this Bond shall be construed as a statutory bond and not as a common law bond.

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12. Definitions.

12.1. *Balance of the Contract Price:* The total amount payable by Buyer to Seller under the Contract after all proper adjustments have been made, including allowance to Seller of any amounts received or to be received by Buyer in settlement of insurance or other Claims for damages to which Seller is entitled, reduced by all valid and proper payments made to or on behalf of Seller under the Contract.

12.2. *Contract:* The agreement between Buyer and Seller identified on the signature page, including all Contract Documents and changes thereto.

12.3. *Seller Default:* Failure of Seller, which has neither been remedied nor waived, to perform or otherwise to comply with the terms of the Contract.

12.4. *Buyer Default:* Failure of Buyer, which has neither been remedied nor waived, to pay Seller as required by the Contract or to perform and complete or comply with the other terms thereof.

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PAYMENT BOND
FOR PROCUREMENT CONTRACTS

Any singular reference to Seller, Surety, Buyer or other party shall be considered plural where applicable.

SELLER (Name and Address):

SURETY (Name and Address of Principal Place of Business):

BUYER (Name and Address):

CONTRACT
Date:
Amount:
Description (Name and Location):

BOND
Date (Not earlier than Contract Date):
Bond Number:
Amount:
Modifications to this Bond Form:

Surety and Seller, intending to be legally bound hereby, subject to the terms set forth below, do each cause this Payment Bond to be duly executed on its behalf by its authorized officer, agent, or representative.

Seller as Principal
Company: (Corp. Seal)

Signature:
Name and Title:

Surety
Company: (Corp. Seal)

Signature:
Name and Title:
(Attach Power of Attorney)
Address:
Telephone Number:

(Space is provided below for signatures of additional parties, if required.)

Seller as Principal
Company: (Corp. Seal)

Signature:
Name and Title:

Surety
Company: (Corp. Seal)

Signature:
Name and Title:
Address:
Telephone Number:

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1. Seller and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns to Buyer to pay for labor, materials and equipment furnished for use in the performance of the Contract, which is incorporated herein by reference. For purposes of this bond, Buyer means Buyer's assigns, if and when Buyer has assigned the Contract.

2. With respect to Buyer, this obligation shall be null and void if Seller:

   2.1. Promptly makes payment, directly or indirectly, for all sums due Claimants, and

   2.2. Defends, indemnifies and holds harmless Buyer from all claims, demands, liens or suits by any person or entity who furnished labor, materials or equipment for use in the performance of the Contract, provided Buyer has promptly notified Seller and Surety (at the addresses described in Paragraph 12) of any claims, demands, liens or suits and tendered defense of such claims, demands, liens or suits to Seller and Surety, and provided there is no Buyer Default.

3. With respect to Claimants, this obligation shall be null and void if Seller promptly makes payment, directly or indirectly, for all sums due.

4. Surety shall have no obligation to Claimants under this Bond until:

   4.1. Claimants who are employed by or have a direct contract with Seller have given notice to Surety (at the address described in Paragraph 12) and sent a copy, or notice thereof, to Buyer stating that a claim is being made under this Bond and, with substantial accuracy, the amount of the claim.

   4.2. Claimants who do not have a direct contract with Seller:

      a. Have furnished written notice to Seller and sent a copy, or notice thereof, to Buyer, within 90 days after having last performed labor or last furnished materials or equipment included in the claim stating, with substantial accuracy, the amount of the claim and the name of the party to whom the materials were furnished or supplied or for whom the labor was done or performed; and

      b. Have either received a rejection in whole or in part from Seller or not received within 30 days of furnishing the above notice any communication from Seller by which Seller had indicated the claim will be paid directly or indirectly; and

      c. Not having been paid within the above 30 days, have sent a written notice to Surety (at the address described in Paragraph 12) and sent a copy, or notice thereof, to Buyer stating that a claim is being made under this Bond and enclosing a copy of the previous written notice furnished to Seller.

5. If a notice required by Paragraph 4 is given by Buyer to Seller or to Surety, that is sufficient compliance.

6. Reserved.

7. Surety's total obligation shall not exceed the amount of this Bond, and the amount of this bond shall be credited for any payments made in good faith by Surety.

8. Amounts owed by Buyer to Seller under the Contract shall be used for the performance of the Contract and to satisfy claims, if any, under any Performance Bond. By Seller furnishing and Buyer

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accepting this Bond, they agree that all funds earned by Seller in the performance of the Contract are dedicated to satisfy obligations of Seller and Surety under this Bond, subject to Buyer's priority to use the funds for the completion of the furnishing the Goods and Special Services.

9. Surety shall not be liable to Buyer, Claimants or others for obligations of Seller that are unrelated to the Contract. Buyer shall not be liable for payment of any costs or expenses of any Claimant under this Bond, and shall have under this Bond no obligation to make payments to, give notices on behalf of, or otherwise have obligations to Claimants under this Bond.

10. Surety hereby waives notice of any change, including changes of time, to the Contract or to related subcontracts, purchase orders, and other obligations.

11. No suit or action shall be commenced by a Claimant under this Bond other than in a court of competent jurisdiction in the location in which the Goods relevant to the claim are located or after the expiration of one year from the date (1) on which the Claimant gave the notice required by Paragraph 4.1 or paragraph 4.2.3, or (2) on which the last labor or service was performed by anyone or the last materials or equipment were furnished by anyone under the Contract, whichever of (1) or (2) first occurs. If the provisions of this paragraph are void or prohibited by law, the minimum period of limitation available to sureties as a defense in the jurisdiction of the suit shall be applicable.

12. Notice to Surety, Buyer or Seller shall be mailed or delivered to the addresses shown on the signature page. Actual receipt of notice by Surety, Buyer or Seller, however accomplished, shall be sufficient compliance as of the date received at the address shown on the signature page.

13. When this Bond has been furnished to comply with a statutory or other legal requirement in the location where the Contract was to be performed, any provision in this Bond conflicting with said statutory or legal requirement shall be deemed deleted herefrom and provisions conforming to such statutory or other legal requirement shall be deemed incorporated herein. The intent is that this Bond shall be construed as a statutory Bond and not as a common law bond.

14. Upon request of any person or entity appearing to be a potential beneficiary of this Bond, Seller shall promptly furnish a copy of this Bond or shall permit a copy to be made.

15. Definitions

    15.1 *Claimant:* An individual or entity having a direct contract with Seller or with a Subcontractor of Seller to furnish labor, materials or equipment for use in the performance of the Contract. The intent of this Bond shall be to include without limitation in the terms "labor, materials or equipment" that part of water, gas, power, light, heat, oil, gasoline, telephone service or rental equipment used in the Contract, architectural and engineering services required for furnishing the Goods and Special Services by Seller and Seller's Subcontractors, and all other items for which a mechanic's lien may be asserted in the jurisdiction where the labor, materials or equipment were furnished.

    15.2. *Contract:* The agreement between Buyer and Seller identified on the signature page, including all Contract Documents and changes thereto.

    15.3. *Buyer Default:* Failure of Buyer, which has neither been remedied nor waived, to pay Seller as required by the Contract or to perform and complete or comply with the other terms thereof.

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STANDARD GENERAL CONDITIONS OF THE CONSTRUCTION CONTRACT

Prepared by

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CONSTRUCTION SPECIFICATIONS INSTITUTE

These General Conditions have been prepared for use with the Suggested Forms of Agreement Between Owner and Contractor (EJCDC C-520 or C-525, 2007 Editions). Their provisions are interrelated and a change in one may necessitate a change in the other. Comments concerning their usage are contained in the Narrative Guide to the EJCDC Construction Documents (EJCDC C-001, 2007 Edition). For guidance in the preparation of Supplementary Conditions, see Guide to the Preparation of Supplementary Conditions (EJCDC C-800, 2007 Edition).

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1420 King Street, Alexandria, VA 22314-2794
(703) 684-2882
www.nspe.org

American Council of Engineering Companies
1015 15th Street N.W., Washington, DC 20005
(202) 347-7474
www.acec.org

American Society of Civil Engineers
1801 Alexander Bell Drive, Reston, VA 20191-4400
(800) 548-2723
www.asce.org

Associated General Contractors of America
2300 Wilson Boulevard, Suite 400, Arlington, VA 22201-3308
(703) 548-3118
www.agc.org

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STANDARD GENERAL CONDITIONS OF THE
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ARTICLE 1 – DEFINITIONS AND TERMINOLOGY

1.01 *Defined Terms*

A. Wherever used in the Bidding Requirements or Contract Documents and printed with initial capital letters, the terms listed below will have the meanings indicated which are applicable to both the singular and plural thereof. In addition to terms specifically defined, terms with initial capital letters in the Contract Documents include references to identified articles and paragraphs, and the titles of other documents or forms.

1. *Addenda*—Written or graphic instruments issued prior to the opening of Bids which clarify, correct, or change the Bidding Requirements or the proposed Contract Documents.

2. *Agreement*—The written instrument which is evidence of the agreement between Owner and Contractor covering the Work.

3. *Application for Payment*—The form acceptable to Engineer which is to be used by Contractor during the course of the Work in requesting progress or final payments and which is to be accompanied by such supporting documentation as is required by the Contract Documents.

4. *Asbestos*—Any material that contains more than one percent asbestos and is friable or is releasing asbestos fibers into the air above current action levels established by the United States Occupational Safety and Health Administration.

5. *Bid*—The offer or proposal of a Bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

6. *Bidder*—The individual or entity who submits a Bid directly to Owner.

7. *Bidding Documents*—The Bidding Requirements and the proposed Contract Documents (including all Addenda).

8. *Bidding Requirements*—The advertisement or invitation to bid, Instructions to Bidders, Bid security of acceptable form, if any, and the Bid Form with any supplements.

9. *Change Order*—A document recommended by Engineer which is signed by Contractor and Owner and authorizes an addition, deletion, or revision in the Work or an adjustment in the Contract Price or the Contract Times, issued on or after the Effective Date of the Agreement.

10. *Claim*—A demand or assertion by Owner or Contractor seeking an adjustment of Contract Price or Contract Times, or both, or other relief with respect to the terms of the Contract. A demand for money or services by a third party is not a Claim.

11. *Contract*—The entire and integrated written agreement between the Owner and Contractor concerning the Work. The Contract supersedes prior negotiations, representations, or agreements, whether written or oral.

12. *Contract Documents*—Those items so designated in the Agreement. Only printed or hard copies of the items listed in the Agreement are Contract Documents. Approved Shop Drawings, other Contractor submittals, and the reports and drawings of subsurface and physical conditions are not Contract Documents.

13. *Contract Price*—The moneys payable by Owner to Contractor for completion of the Work in accordance with the Contract Documents as stated in the Agreement (subject to the provisions of Paragraph 11.03 in the case of Unit Price Work).

14. *Contract Times*—The number of days or the dates stated in the Agreement to: (i) achieve Milestones, if any; (ii) achieve Substantial Completion; and (iii) complete the Work so that it is ready for final payment as evidenced by Engineer's written recommendation of final payment.

15. *Contractor*—The individual or entity with whom Owner has entered into the Agreement.

16. *Cost of the Work*—See Paragraph 11.01 for definition.

17. *Drawings*—That part of the Contract Documents prepared or approved by Engineer which graphically shows the scope, extent, and character of the Work to be

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performed by Contractor. Shop Drawings and other Contractor submittals are not Drawings as so defined.

18. *Effective Date of the Agreement*—The date indicated in the Agreement on which it becomes effective, but if no such date is indicated, it means the date on which the Agreement is signed and delivered by the last of the two parties to sign and deliver.

19. *Engineer*—The individual or entity named as such in the Agreement.

20. *Field Order*—A written order issued by Engineer which requires minor changes in the Work but which does not involve a change in the Contract Price or the Contract Times.

21. *General Requirements*—Sections of Division 1 of the Specifications.

22. *Hazardous Environmental Condition*—The presence at the Site of Asbestos, PCBs, Petroleum, Hazardous Waste, or Radioactive Material in such quantities or circumstances that may present a substantial danger to persons or property exposed thereto.

23. *Hazardous Waste*—The term Hazardous Waste shall have the meaning provided in Section 1004 of the Solid Waste Disposal Act (42 USC Section 6903) as amended from time to time.

24. *Laws and Regulations; Laws or Regulations*—Any and all applicable laws, rules, regulations, ordinances, codes, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.

25. *Liens*—Charges, security interests, or encumbrances upon Project funds, real property, or personal property.

26. *Milestone*—A principal event specified in the Contract Documents relating to an intermediate completion date or time prior to Substantial Completion of all the Work.

27. *Notice of Award*—The written notice by Owner to the Successful Bidder stating that upon timely compliance by the Successful Bidder with the conditions precedent listed therein, Owner will sign and deliver the Agreement.

28. *Notice to Proceed*—A written notice given by Owner to Contractor fixing the date on which the Contract Times will commence to run and on which Contractor shall start to perform the Work under the Contract Documents.

29. *Owner*—The individual or entity with whom Contractor has entered into the Agreement and for whom the Work is to be performed.

30. *PCBs*—Polychlorinated biphenyls.

31. *Petroleum*—Petroleum, including crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute), such as oil, petroleum, fuel oil, oil sludge, oil refuse, gasoline, kerosene, and oil mixed with other non-Hazardous Waste and crude oils.

32. *Progress Schedule*—A schedule, prepared and maintained by Contractor, describing the sequence and duration of the activities comprising the Contractor's plan to accomplish the Work within the Contract Times.

33. *Project*—The total construction of which the Work to be performed under the Contract Documents may be the whole, or a part.

34. *Project Manual*—The bound documentary information prepared for bidding and constructing the Work. A listing of the contents of the Project Manual, which may be bound in one or more volumes, is contained in the table(s) of contents.

35. *Radioactive Material*—Source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954 (42 USC Section 2011 et seq.) as amended from time to time.

36. *Resident Project Representative*—The authorized representative of Engineer who may be assigned to the Site or any part thereof.

37. *Samples*—Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work

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and which establish the standards by which such portion of the Work will be judged.

38. *Schedule of Submittals*—A schedule, prepared and maintained by Contractor, of required submittals and the time requirements to support scheduled performance of related construction activities.

39. *Schedule of Values*—A schedule, prepared and maintained by Contractor, allocating portions of the Contract Price to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

40. *Shop Drawings*—All drawings, diagrams, illustrations, schedules, and other data or information which are specifically prepared or assembled by or for Contractor and submitted by Contractor to illustrate some portion of the Work.

41. *Site*—Lands or areas indicated in the Contract Documents as being furnished by Owner upon which the Work is to be performed, including rights-of-way and easements for access thereto, and such other lands furnished by Owner which are designated for the use of Contractor.

42. *Specifications*—That part of the Contract Documents consisting of written requirements for materials, equipment, systems, standards and workmanship as applied to the Work, and certain administrative requirements and procedural matters applicable thereto.

43. *Subcontractor*—An individual or entity having a direct contract with Contractor or with any other Subcontractor for the performance of a part of the Work at the Site.

44. *Substantial Completion*—The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of Engineer, the Work (or a specified part thereof) is sufficiently complete, in accordance with the Contract Documents, so that the Work (or a specified part thereof) can be utilized for the purposes for which it is intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion thereof.

45. *Successful Bidder*—The Bidder submitting a responsive Bid to whom Owner makes an award.

46. *Supplementary Conditions*—That part of the Contract Documents which amends or supplements these General Conditions.

47. *Supplier*—A manufacturer, fabricator, supplier, distributor, materialman, or vendor having a direct contract with Contractor or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by Contractor or Subcontractor.

48. *Underground Facilities*—All underground pipelines, conduits, ducts, cables, wires, manholes, vaults, tanks, tunnels, or other such facilities or attachments, and any encasements containing such facilities, including those that convey electricity, gases, steam, liquid petroleum products, telephone or other communications, cable television, water, wastewater, storm water, other liquids or chemicals, or traffic or other control systems.

49. *Unit Price Work*—Work to be paid for on the basis of unit prices.

50. *Work*—The entire construction or the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services, and documentation necessary to produce such construction, and furnishing, installing, and incorporating all materials and equipment into such construction, all as required by the Contract Documents.

51. *Work Change Directive*—A written statement to Contractor issued on or after the Effective Date of the Agreement and signed by Owner and recommended by Engineer ordering an addition, deletion, or revision in the Work, or responding to differing or unforeseen subsurface or physical conditions under which the Work is to be performed or to emergencies. A Work Change Directive will not change the Contract Price or the Contract Times but is evidence that the parties expect that the change ordered or documented by a Work Change Directive will be incorporated in a subsequently issued Change Order following negotiations by the parties as to its

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effect, if any, on the Contract Price or Contract Times.

1.02 *Terminology*

A. The words and terms discussed in Paragraph 1.02.B through F are not defined but, when used in the Bidding Requirements or Contract Documents, have the indicated meaning.

B. *Intent of Certain Terms or Adjectives:*

1. The Contract Documents include the terms "as allowed," "as approved," "as ordered," "as directed" or terms of like effect or import to authorize an exercise of professional judgment by Engineer. In addition, the adjectives "reasonable," "suitable," "acceptable," "proper," "satisfactory," or adjectives of like effect or import are used to describe an action or determination of Engineer as to the Work. It is intended that such exercise of professional judgment, action, or determination will be solely to evaluate, in general, the Work for compliance with the information in the Contract Documents and with the design concept of the Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective is not intended to and shall not be effective to assign to Engineer any duty or authority to supervise or direct the performance of the Work, or any duty or authority to undertake responsibility contrary to the provisions of Paragraph 9.09 or any other provision of the Contract Documents.

C. *Day:*

1. The word "day" means a calendar day of 24 hours measured from midnight to the next midnight.

D. *Defective:*

1. The word "defective," when modifying the word "Work," refers to Work that is unsatisfactory, faulty, or deficient in that it:

a. does not conform to the Contract Documents; or

b. does not meet the requirements of any applicable inspection, reference standard, test, or approval referred to in the Contract Documents; or

c. has been damaged prior to Engineer's recommendation of final payment (unless responsibility for the protection thereof has been assumed by Owner at Substantial Completion in accordance with Paragraph 14.04 or 14.05).

E. *Furnish, Install, Perform, Provide:*

1. The word "furnish," when used in connection with services, materials, or equipment, shall mean to supply and deliver said services, materials, or equipment to the Site (or some other specified location) ready for use or installation and in usable or operable condition.

2. The word "install," when used in connection with services, materials, or equipment, shall mean to put into use or place in final position said services, materials, or equipment complete and ready for intended use.

3. The words "perform" or "provide," when used in connection with services, materials, or equipment, shall mean to furnish and install said services, materials, or equipment complete and ready for intended use.

4. When "furnish," "install," "perform," or "provide" is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of Contractor, "provide" is implied.

F. Unless stated otherwise in the Contract Documents, words or phrases that have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

ARTICLE 2 – PRELIMINARY MATTERS

2.01 *Delivery of Bonds and Evidence of Insurance*

A. When Contractor delivers the executed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner such bonds as Contractor may be required to furnish.

B. *Evidence of Insurance:* Before any Work at the Site is started, Contractor and Owner shall each deliver to the other, with copies to each additional

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insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance which either of them or any additional insured may reasonably request) which Contractor and Owner respectively are required to purchase and maintain in accordance with Article 5.

2.02 *Copies of Documents*

A. Owner shall furnish to Contractor up to ten printed or hard copies of the Drawings and Project Manual. Additional copies will be furnished upon request at the cost of reproduction.

2.03 *Commencement of Contract Times; Notice to Proceed*

A. The Contract Times will commence to run on the thirtieth day after the Effective Date of the Agreement or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Agreement. In no event will the Contract Times commence to run later than the sixtieth day after the day of Bid opening or the thirtieth day after the Effective Date of the Agreement, whichever date is earlier.

2.04 *Starting the Work*

A. Contractor shall start to perform the Work on the date when the Contract Times commence to run. No Work shall be done at the Site prior to the date on which the Contract Times commence to run.

2.05 *Before Starting Construction*

A. *Preliminary Schedules:* Within 10 days after the Effective Date of the Agreement (unless otherwise specified in the General Requirements), Contractor shall submit to Engineer for timely review:

1. a preliminary Progress Schedule indicating the times (numbers of days or dates) for starting and completing the various stages of the Work, including any Milestones specified in the Contract Documents;

2. a preliminary Schedule of Submittals; and

3. a preliminary Schedule of Values for all of the Work which includes quantities and prices of items which when added together equal the Contract Price and subdivides the Work into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

2.06 *Preconstruction Conference; Designation of Authorized Representatives*

A. Before any Work at the Site is started, a conference attended by Owner, Contractor, Engineer, and others as appropriate will be held to establish a working understanding among the parties as to the Work and to discuss the schedules referred to in Paragraph 2.05.A, procedures for handling Shop Drawings and other submittals, processing Applications for Payment, and maintaining required records.

B. At this conference Owner and Contractor each shall designate, in writing, a specific individual to act as its authorized representative with respect to the services and responsibilities under the Contract. Such individuals shall have the authority to transmit instructions, receive information, render decisions relative to the Contract, and otherwise act on behalf of each respective party.

2.07 *Initial Acceptance of Schedules*

A. At least 10 days before submission of the first Application for Payment a conference attended by Contractor, Engineer, and others as appropriate will be held to review for acceptability to Engineer as provided below the schedules submitted in accordance with Paragraph 2.05.A. Contractor shall have an additional 10 days to make corrections and adjustments and to complete and resubmit the schedules. No progress payment shall be made to Contractor until acceptable schedules are submitted to Engineer.

1. The Progress Schedule will be acceptable to Engineer if it provides an orderly progression of the Work to completion within the Contract Times. Such acceptance will not impose on Engineer responsibility for the Progress Schedule, for sequencing, scheduling, or progress of the Work, nor interfere with or relieve Contractor from Contractor's full responsibility therefor.

2. Contractor's Schedule of Submittals will be acceptable to Engineer if it provides a

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workable arrangement for reviewing and processing the required submittals.

3. Contractor's Schedule of Values will be acceptable to Engineer as to form and substance if it provides a reasonable allocation of the Contract Price to component parts of the Work.

ARTICLE 3 – CONTRACT DOCUMENTS: INTENT, AMENDING, REUSE

3.01 *Intent*

A. The Contract Documents are complementary; what is required by one is as binding as if required by all.

B. It is the intent of the Contract Documents to describe a functionally complete project (or part thereof) to be constructed in accordance with the Contract Documents. Any labor, documentation, services, materials, or equipment that reasonably may be inferred from the Contract Documents or from prevailing custom or trade usage as being required to produce the indicated result will be provided whether or not specifically called for, at no additional cost to Owner.

C. Clarifications and interpretations of the Contract Documents shall be issued by Engineer as provided in Article 9.

3.02 *Reference Standards*

A. Standards, Specifications, Codes, Laws, and Regulations

1. Reference to standards, specifications, manuals, or codes of any technical society, organization, or association, or to Laws or Regulations, whether such reference be specific or by implication, shall mean the standard, specification, manual, code, or Laws or Regulations in effect at the time of opening of Bids (or on the Effective Date of the Agreement if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.

2. No provision of any such standard, specification, manual, or code, or any instruction of a Supplier, shall be effective to change the duties or responsibilities of Owner, Contractor, or Engineer, or any of their subcontractors, consultants, agents, or employees, from those set forth in the Contract Documents. No such provision or instruction shall be effective to assign to Owner, Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, any duty or authority to supervise or direct the performance of the Work or any duty or authority to undertake responsibility inconsistent with the provisions of the Contract Documents.

3.03 *Reporting and Resolving Discrepancies*

A. *Reporting Discrepancies:*

1. *Contractor's Review of Contract Documents Before Starting Work*: Before undertaking each part of the Work, Contractor shall carefully study and compare the Contract Documents and check and verify pertinent figures therein and all applicable field measurements. Contractor shall promptly report in writing to Engineer any conflict, error, ambiguity, or discrepancy which Contractor discovers, or has actual knowledge of, and shall obtain a written interpretation or clarification from Engineer before proceeding with any Work affected thereby.

2. *Contractor's Review of Contract Documents During Performance of Work*: If, during the performance of the Work, Contractor discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents, or between the Contract Documents and (a) any applicable Law or Regulation , (b) any standard, specification, manual, or code, or (c) any instruction of any Supplier, then Contractor shall promptly report it to Engineer in writing. Contractor shall not proceed with the Work affected thereby (except in an emergency as required by Paragraph 6.16.A) until an amendment or supplement to the Contract Documents has been issued by one of the methods indicated in Paragraph 3.04.

3. Contractor shall not be liable to Owner or Engineer for failure to report any conflict, error, ambiguity, or discrepancy in the Contract Documents unless Contractor had actual knowledge thereof.

B. *Resolving Discrepancies:*

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1. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the Contract Documents shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between the provisions of the Contract Documents and:

   a. the provisions of any standard, specification, manual, or code, or the instruction of any Supplier (whether or not specifically incorporated by reference in the Contract Documents); or

   b. the provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 *Amending and Supplementing Contract Documents*

A. The Contract Documents may be amended to provide for additions, deletions, and revisions in the Work or to modify the terms and conditions thereof by either a Change Order or a Work Change Directive.

B. The requirements of the Contract Documents may be supplemented, and minor variations and deviations in the Work may be authorized, by one or more of the following ways:

   1. A Field Order;

   2. Engineer's approval of a Shop Drawing or Sample (subject to the provisions of Paragraph 6.17.D.3); or

   3. Engineer's written interpretation or clarification.

3.05 *Reuse of Documents*

A. Contractor and any Subcontractor or Supplier shall not:

   1. have or acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of Engineer or its consultants, including electronic media editions; or

   2. reuse any such Drawings, Specifications, other documents, or copies thereof on extensions of the Project or any other project without written consent of Owner and Engineer and specific written verification or adaptation by Engineer.

B. The prohibitions of this Paragraph 3.05 will survive final payment, or termination of the Contract. Nothing herein shall preclude Contractor from retaining copies of the Contract Documents for record purposes.

3.06 *Electronic Data*

A. Unless otherwise stated in the Supplementary Conditions, the data furnished by Owner or Engineer to Contractor, or by Contractor to Owner or Engineer, that may be relied upon are limited to the printed copies (also known as hard copies). Files in electronic media format of text, data, graphics, or other types are furnished only for the convenience of the receiving party. Any conclusion or information obtained or derived from such electronic files will be at the user's sole risk. If there is a discrepancy between the electronic files and the hard copies, the hard copies govern.

B. Because data stored in electronic media format can deteriorate or be modified inadvertently or otherwise without authorization of the data's creator, the party receiving electronic files agrees that it will perform acceptance tests or procedures within 60 days, after which the receiving party shall be deemed to have accepted the data thus transferred. Any errors detected within the 60-day acceptance period will be corrected by the transferring party.

C. When transferring documents in electronic media format, the transferring party makes no representations as to long term compatibility, usability, or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by the data's creator.

ARTICLE 4 – AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS; REFERENCE POINTS

4.01 *Availability of Lands*

A. Owner shall furnish the Site. Owner shall notify Contractor of any encumbrances or restrictions not of general application but specifically related to

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use of the Site with which Contractor must comply in performing the Work. Owner will obtain in a timely manner and pay for easements for permanent structures or permanent changes in existing facilities. If Contractor and Owner are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, as a result of any delay in Owner's furnishing the Site or a part thereof, Contractor may make a Claim therefor as provided in Paragraph 10.05.

B. Upon reasonable written request, Owner shall furnish Contractor with a current statement of record legal title and legal description of the lands upon which the Work is to be performed and Owner's interest therein as necessary for giving notice of or filing a mechanic's or construction lien against such lands in accordance with applicable Laws and Regulations.

C. Contractor shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

4.02 *Subsurface and Physical Conditions*

A. *Reports and Drawings:* The Supplementary Conditions identify:

1. those reports known to Owner of explorations and tests of subsurface conditions at or contiguous to the Site; and

2. those drawings known to Owner of physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities).

B. *Limited Reliance by Contractor on Technical Data Authorized:* Contractor may rely upon the accuracy of the "technical data" contained in such reports and drawings, but such reports and drawings are not Contract Documents. Such "technical data" is identified in the Supplementary Conditions. Except for such reliance on such "technical data," Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, and safety precautions and programs incident thereto; or

2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings; or

3. any Contractor interpretation of or conclusion drawn from any "technical data" or any such other data, interpretations, opinions, or information.

4.03 *Differing Subsurface or Physical Conditions*

A. *Notice:* If Contractor believes that any subsurface or physical condition that is uncovered or revealed either:

1. is of such a nature as to establish that any "technical data" on which Contractor is entitled to rely as provided in Paragraph 4.02 is materially inaccurate; or

2. is of such a nature as to require a change in the Contract Documents; or

3. differs materially from that shown or indicated in the Contract Documents; or

4. is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents;

then Contractor shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by Paragraph 6.16.A), notify Owner and Engineer in writing about such condition. Contractor shall not further disturb such condition or perform any Work in connection therewith (except as aforesaid) until receipt of written order to do so.

B. *Engineer's Review*: After receipt of written notice as required by Paragraph 4.03.A, Engineer will promptly review the pertinent condition, determine the necessity of Owner's obtaining additional exploration or tests with respect thereto, and advise Owner in writing (with a copy to Contractor) of Engineer's findings and conclusions.

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C. *Possible Price and Times Adjustments:*

1. The Contract Price or the Contract Times, or both, will be equitably adjusted to the extent that the existence of such differing subsurface or physical condition causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:

    a. such condition must meet any one or more of the categories described in Paragraph 4.03.A; and

    b. with respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will be subject to the provisions of Paragraphs 9.07 and 11.03.

2. Contractor shall not be entitled to any adjustment in the Contract Price or Contract Times if:

    a. Contractor knew of the existence of such conditions at the time Contractor made a final commitment to Owner with respect to Contract Price and Contract Times by the submission of a Bid or becoming bound under a negotiated contract; or

    b. the existence of such condition could reasonably have been discovered or revealed as a result of any examination, investigation, exploration, test, or study of the Site and contiguous areas required by the Bidding Requirements or Contract Documents to be conducted by or for Contractor prior to Contractor's making such final commitment; or

    c. Contractor failed to give the written notice as required by Paragraph 4.03.A.

3. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, a Claim may be made therefor as provided in Paragraph 10.05. However, neither Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors shall be liable to Contractor for any claims, costs, losses, or damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by Contractor on or in connection with any other project or anticipated project.

4.04 *Underground Facilities*

A. *Shown or Indicated:* The information and data shown or indicated in the Contract Documents with respect to existing Underground Facilities at or contiguous to the Site is based on information and data furnished to Owner or Engineer by the owners of such Underground Facilities, including Owner, or by others. Unless it is otherwise expressly provided in the Supplementary Conditions:

1. Owner and Engineer shall not be responsible for the accuracy or completeness of any such information or data provided by others; and

2. the cost of all of the following will be included in the Contract Price, and Contractor shall have full responsibility for:

    a. reviewing and checking all such information and data;

    b. locating all Underground Facilities shown or indicated in the Contract Documents;

    c. coordination of the Work with the owners of such Underground Facilities, including Owner, during construction; and

    d. the safety and protection of all such Underground Facilities and repairing any damage thereto resulting from the Work.

B. *Not Shown or Indicated:*

1. If an Underground Facility is uncovered or revealed at or contiguous to the Site which was not shown or indicated, or not shown or indicated with reasonable accuracy in the Contract Documents, Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by Paragraph 6.16.A), identify the owner of such Underground Facility and give written notice to that owner and to Owner and Engineer. Engineer will promptly review the Underground Facility and determine the

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extent, if any, to which a change is required in the Contract Documents to reflect and document the consequences of the existence or location of the Underground Facility. During such time, Contractor shall be responsible for the safety and protection of such Underground Facility.

2. If Engineer concludes that a change in the Contract Documents is required, a Work Change Directive or a Change Order will be issued to reflect and document such consequences. An equitable adjustment shall be made in the Contract Price or Contract Times, or both, to the extent that they are attributable to the existence or location of any Underground Facility that was not shown or indicated or not shown or indicated with reasonable accuracy in the Contract Documents and that Contractor did not know of and could not reasonably have been expected to be aware of or to have anticipated. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment in Contract Price or Contract Times, Owner or Contractor may make a Claim therefor as provided in Paragraph 10.05.

4.05 *Reference Points*

A. Owner shall provide engineering surveys to establish reference points for construction which in Engineer's judgment are necessary to enable Contractor to proceed with the Work. Contractor shall be responsible for laying out the Work, shall protect and preserve the established reference points and property monuments, and shall make no changes or relocations without the prior written approval of Owner. Contractor shall report to Engineer whenever any reference point or property monument is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points or property monuments by professionally qualified personnel.

4.06 *Hazardous Environmental Condition at Site*

A. *Reports and Drawings:* The Supplementary Conditions identify those reports and drawings known to Owner relating to Hazardous Environmental Conditions that have been identified at the Site.

B. *Limited Reliance by Contractor on Technical Data Authorized:* Contractor may rely upon the accuracy of the "technical data" contained in such reports and drawings, but such reports and drawings are not Contract Documents. Such "technical data" is identified in the Supplementary Conditions. Except for such reliance on such "technical data," Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences and procedures of construction to be employed by Contractor and safety precautions and programs incident thereto; or

2. other data, interpretations, opinions and information contained in such reports or shown or indicated in such drawings; or

3. any Contractor interpretation of or conclusion drawn from any "technical data" or any such other data, interpretations, opinions or information.

C. Contractor shall not be responsible for any Hazardous Environmental Condition uncovered or revealed at the Site which was not shown or indicated in Drawings or Specifications or identified in the Contract Documents to be within the scope of the Work. Contractor shall be responsible for a Hazardous Environmental Condition created with any materials brought to the Site by Contractor, Subcontractors, Suppliers, or anyone else for whom Contractor is responsible.

D. If Contractor encounters a Hazardous Environmental Condition or if Contractor or anyone for whom Contractor is responsible creates a Hazardous Environmental Condition, Contractor shall immediately: (i) secure or otherwise isolate such condition; (ii) stop all Work in connection with such condition and in any area affected thereby (except in an emergency as required by Paragraph 6.16.A); and (iii) notify Owner and Engineer (and promptly thereafter confirm such notice in writing). Owner shall promptly consult with Engineer concerning the necessity for Owner to retain a qualified expert to evaluate such condition or take corrective action,

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if any. Promptly after consulting with Engineer, Owner shall take such actions as are necessary to permit Owner to timely obtain required permits and provide Contractor the written notice required by Paragraph 4.06.E.

E. Contractor shall not be required to resume Work in connection with such condition or in any affected area until after Owner has obtained any required permits related thereto and delivered written notice to Contractor: (i) specifying that such condition and any affected area is or has been rendered safe for the resumption of Work; or (ii) specifying any special conditions under which such Work may be resumed safely. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times, or both, as a result of such Work stoppage or such special conditions under which Work is agreed to be resumed by Contractor, either party may make a Claim therefor as provided in Paragraph 10.05.

F. If after receipt of such written notice Contractor does not agree to resume such Work based on a reasonable belief it is unsafe, or does not agree to resume such Work under such special conditions, then Owner may order the portion of the Work that is in the area affected by such condition to be deleted from the Work. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of an adjustment in Contract Price or Contract Times as a result of deleting such portion of the Work, then either party may make a Claim therefor as provided in Paragraph 10.05. Owner may have such deleted portion of the Work performed by Owner's own forces or others in accordance with Article 7.

G. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition, provided that such Hazardous Environmental Condition: (i) was not shown or indicated in the Drawings or Specifications or identified in the Contract Documents to be included within the scope of the Work, and (ii) was not created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 4.06.G shall obligate Owner to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

H. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 4.06.H shall obligate Contractor to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

I. The provisions of Paragraphs 4.02, 4.03, and 4.04 do not apply to a Hazardous Environmental Condition uncovered or revealed at the Site.

ARTICLE 5 – BONDS AND INSURANCE

5.01 *Performance, Payment, and Other Bonds*

A. Contractor shall furnish performance and payment bonds, each in an amount at least equal to the Contract Price as security for the faithful performance and payment of all of Contractor's obligations under the Contract Documents. These bonds shall remain in effect until one year after the date when final payment becomes due or until completion of the correction period specified in Paragraph 13.07, whichever is later, except as provided otherwise by Laws or Regulations or by the Contract Documents. Contractor shall also furnish such other bonds as are required by the Contract Documents.

B. All bonds shall be in the form prescribed by the Contract Documents except as provided otherwise by Laws or Regulations, and shall be executed by such sureties as are named in the list of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Circular 570 (amended) by the Financial Management Service, Surety Bond Branch, U.S. Department of the Treasury. All bonds signed by

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an agent or attorney-in-fact must be accompanied by a certified copy of that individual's authority to bind the surety. The evidence of authority shall show that it is effective on the date the agent or attorney-in-fact signed each bond.

C. If the surety on any bond furnished by Contractor is declared bankrupt or becomes insolvent or its right to do business is terminated in any state where any part of the Project is located or it ceases to meet the requirements of Paragraph 5.01.B, Contractor shall promptly notify Owner and Engineer and shall, within 20 days after the event giving rise to such notification, provide another bond and surety, both of which shall comply with the requirements of Paragraphs 5.01.B and 5.02.

5.02 *Licensed Sureties and Insurers*

A. All bonds and insurance required by the Contract Documents to be purchased and maintained by Owner or Contractor shall be obtained from surety or insurance companies that are duly licensed or authorized in the jurisdiction in which the Project is located to issue bonds or insurance policies for the limits and coverages so required. Such surety and insurance companies shall also meet such additional requirements and qualifications as may be provided in the Supplementary Conditions.

5.03 *Certificates of Insurance*

A. Contractor shall deliver to Owner, with copies to each additional insured and loss payee identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by Owner or any other additional insured) which Contractor is required to purchase and maintain.

B. Owner shall deliver to Contractor, with copies to each additional insured and loss payee identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by Contractor or any other additional insured) which Owner is required to purchase and maintain.

C. Failure of Owner to demand such certificates or other evidence of Contractor's full compliance with these insurance requirements or failure of Owner to identify a deficiency in compliance from the evidence provided shall not be construed as a waiver of Contractor's obligation to maintain such insurance.

D. Owner does not represent that insurance coverage and limits established in this Contract necessarily will be adequate to protect Contractor.

E. The insurance and insurance limits required herein shall not be deemed as a limitation on Contractor's liability under the indemnities granted to Owner in the Contract Documents.

5.04 *Contractor's Insurance*

A. Contractor shall purchase and maintain such insurance as is appropriate for the Work being performed and as will provide protection from claims set forth below which may arise out of or result from Contractor's performance of the Work and Contractor's other obligations under the Contract Documents, whether it is to be performed by Contractor, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to perform any of the Work, or by anyone for whose acts any of them may be liable:

1. claims under workers' compensation, disability benefits, and other similar employee benefit acts;

2. claims for damages because of bodily injury, occupational sickness or disease, or death of Contractor's employees;

3. claims for damages because of bodily injury, sickness or disease, or death of any person other than Contractor's employees;

4. claims for damages insured by reasonably available personal injury liability coverage which are sustained:

   a. by any person as a result of an offense directly or indirectly related to the employment of such person by Contractor, or

   b. by any other person for any other reason;

5. claims for damages, other than to the Work itself, because of injury to or destruction of tangible property wherever located, including loss of use resulting therefrom; and

6. claims for damages because of bodily injury or death of any person or property damage arising out of the ownership, maintenance or use of any motor vehicle.

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B. The policies of insurance required by this Paragraph 5.04 shall:

1. with respect to insurance required by Paragraphs 5.04.A.3 through 5.04.A.6 inclusive, be written on an occurrence basis, include as additional insureds (subject to any customary exclusion regarding professional liability) Owner and Engineer, and any other individuals or entities identified in the Supplementary Conditions, all of whom shall be listed as additional insureds, and include coverage for the respective officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of all such additional insureds, and the insurance afforded to these additional insureds shall provide primary coverage for all claims covered thereby;

2. include at least the specific coverages and be written for not less than the limits of liability provided in the Supplementary Conditions or required by Laws or Regulations, whichever is greater;

3. include contractual liability insurance covering Contractor's indemnity obligations under Paragraphs 6.11 and 6.20;

4. contain a provision or endorsement that the coverage afforded will not be canceled, materially changed or renewal refused until at least 30 days prior written notice has been given to Owner and Contractor and to each other additional insured identified in the Supplementary Conditions to whom a certificate of insurance has been issued (and the certificates of insurance furnished by the Contractor pursuant to Paragraph 5.03 will so provide);

5. remain in effect at least until final payment and at all times thereafter when Contractor may be correcting, removing, or replacing defective Work in accordance with Paragraph 13.07; and

6. include completed operations coverage:

   a. Such insurance shall remain in effect for two years after final payment.

   b. Contractor shall furnish Owner and each other additional insured identified in the Supplementary Conditions, to whom a certificate of insurance has been issued, evidence satisfactory to Owner and any such additional insured of continuation of such insurance at final payment and one year thereafter.

5.05 *Owner's Liability Insurance*

A. In addition to the insurance required to be provided by Contractor under Paragraph 5.04, Owner, at Owner's option, may purchase and maintain at Owner's expense Owner's own liability insurance as will protect Owner against claims which may arise from operations under the Contract Documents.

5.06 *Property Insurance*

A. Unless otherwise provided in the Supplementary Conditions, Owner shall purchase and maintain property insurance upon the Work at the Site in the amount of the full replacement cost thereof (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). This insurance shall:

1. include the interests of Owner, Contractor, Subcontractors, and Engineer, and any other individuals or entities identified in the Supplementary Conditions, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, each of whom is deemed to have an insurable interest and shall be listed as a loss payee;

2. be written on a Builder's Risk "all-risk" policy form that shall at least include insurance for physical loss or damage to the Work, temporary buildings, falsework, and materials and equipment in transit, and shall insure against at least the following perils or causes of loss: fire, lightning, extended coverage, theft, vandalism and malicious mischief, earthquake, collapse, debris removal, demolition occasioned by enforcement of Laws and Regulations, water damage (other than that caused by flood), and such other perils or causes of loss as may be specifically required by the Supplementary Conditions.

3. include expenses incurred in the repair or replacement of any insured property

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(including but not limited to fees and charges of engineers and architects);

4. cover materials and equipment stored at the Site or at another location that was agreed to in writing by Owner prior to being incorporated in the Work, provided that such materials and equipment have been included in an Application for Payment recommended by Engineer;

5. allow for partial utilization of the Work by Owner;

6. include testing and startup; and

7. be maintained in effect until final payment is made unless otherwise agreed to in writing by Owner, Contractor, and Engineer with 30 days written notice to each other loss payee to whom a certificate of insurance has been issued.

B. Owner shall purchase and maintain such equipment breakdown insurance or additional property insurance as may be required by the Supplementary Conditions or Laws and Regulations which will include the interests of Owner, Contractor, Subcontractors, and Engineer, and any other individuals or entities identified in the Supplementary Conditions, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, each of whom is deemed to have an insurable interest and shall be listed as a loss payee.

C. All the policies of insurance (and the certificates or other evidence thereof) required to be purchased and maintained in accordance with this Paragraph 5.06 will contain a provision or endorsement that the coverage afforded will not be canceled or materially changed or renewal refused until at least 30 days prior written notice has been given to Owner and Contractor and to each other loss payee to whom a certificate of insurance has been issued and will contain waiver provisions in accordance with Paragraph 5.07.

D. Owner shall not be responsible for purchasing and maintaining any property insurance specified in this Paragraph 5.06 to protect the interests of Contractor, Subcontractors, or others in the Work to the extent of any deductible amounts that are identified in the Supplementary Conditions. The risk of loss within such identified deductible amount will be borne by Contractor, Subcontractors, or others suffering any such loss, and if any of them wishes property insurance coverage within the limits of such amounts, each may purchase and maintain it at the purchaser's own expense.

E. If Contractor requests in writing that other special insurance be included in the property insurance policies provided under this Paragraph 5.06, Owner shall, if possible, include such insurance, and the cost thereof will be charged to Contractor by appropriate Change Order. Prior to commencement of the Work at the Site, Owner shall in writing advise Contractor whether or not such other insurance has been procured by Owner.

5.07 *Waiver of Rights*

A. Owner and Contractor intend that all policies purchased in accordance with Paragraph 5.06 will protect Owner, Contractor, Subcontractors, and Engineer, and all other individuals or entities identified in the Supplementary Conditions as loss payees (and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them) in such policies and will provide primary coverage for all losses and damages caused by the perils or causes of loss covered thereby. All such policies shall contain provisions to the effect that in the event of payment of any loss or damage the insurers will have no rights of recovery against any of the insureds or loss payees thereunder. Owner and Contractor waive all rights against each other and their respective officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them for all losses and damages caused by, arising out of or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work; and, in addition, waive all such rights against Subcontractors and Engineer, and all other individuals or entities identified in the Supplementary Conditions as loss payees (and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them) under such policies for losses and damages so caused. None of the above waivers shall extend to the rights that any party making such waiver may have to the proceeds of insurance held by Owner as trustee or otherwise payable under any policy so issued.

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B. Owner waives all rights against Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them for:

1. loss due to business interruption, loss of use, or other consequential loss extending beyond direct physical loss or damage to Owner's property or the Work caused by, arising out of, or resulting from fire or other perils whether or not insured by Owner; and

2. loss or damage to the completed Project or part thereof caused by, arising out of, or resulting from fire or other insured peril or cause of loss covered by any property insurance maintained on the completed Project or part thereof by Owner during partial utilization pursuant to Paragraph 14.05, after Substantial Completion pursuant to Paragraph 14.04, or after final payment pursuant to Paragraph 14.07.

C. Any insurance policy maintained by Owner covering any loss, damage or consequential loss referred to in Paragraph 5.07.B shall contain provisions to the effect that in the event of payment of any such loss, damage, or consequential loss, the insurers will have no rights of recovery against Contractor, Subcontractors, or Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them.

5.08 *Receipt and Application of Insurance Proceeds*

A. Any insured loss under the policies of insurance required by Paragraph 5.06 will be adjusted with Owner and made payable to Owner as fiduciary for the loss payees, as their interests may appear, subject to the requirements of any applicable mortgage clause and of Paragraph 5.08.B. Owner shall deposit in a separate account any money so received and shall distribute it in accordance with such agreement as the parties in interest may reach. If no other special agreement is reached, the damaged Work shall be repaired or replaced, the moneys so received applied on account thereof, and the Work and the cost thereof covered by an appropriate Change Order.

B. Owner as fiduciary shall have power to adjust and settle any loss with the insurers unless one of the parties in interest shall object in writing within 15 days after the occurrence of loss to Owner's exercise of this power. If such objection be made, Owner as fiduciary shall make settlement with the insurers in accordance with such agreement as the parties in interest may reach. If no such agreement among the parties in interest is reached, Owner as fiduciary shall adjust and settle the loss with the insurers and, if required in writing by any party in interest, Owner as fiduciary shall give bond for the proper performance of such duties.

5.09 *Acceptance of Bonds and Insurance; Option to Replace*

A. If either Owner or Contractor has any objection to the coverage afforded by or other provisions of the bonds or insurance required to be purchased and maintained by the other party in accordance with Article 5 on the basis of non-conformance with the Contract Documents, the objecting party shall so notify the other party in writing within 10 days after receipt of the certificates (or other evidence requested) required by Paragraph 2.01.B. Owner and Contractor shall each provide to the other such additional information in respect of insurance provided as the other may reasonably request. If either party does not purchase or maintain all of the bonds and insurance required of such party by the Contract Documents, such party shall notify the other party in writing of such failure to purchase prior to the start of the Work, or of such failure to maintain prior to any change in the required coverage. Without prejudice to any other right or remedy, the other party may elect to obtain equivalent bonds or insurance to protect such other party's interests at the expense of the party who was required to provide such coverage, and a Change Order shall be issued to adjust the Contract Price accordingly.

5.10 *Partial Utilization, Acknowledgment of Property Insurer*

A. If Owner finds it necessary to occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work as provided in Paragraph 14.05, no such use or occupancy shall commence before the insurers providing the property insurance pursuant to Paragraph 5.06 have acknowledged notice thereof and in writing effected any changes in coverage necessitated thereby. The insurers providing the property insurance shall consent by endorsement on the policy or policies, but the property insurance shall not be canceled or permitted to lapse on account of any such partial use or occupancy.

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ARTICLE 6 – CONTRACTOR'S RESPONSIBILITIES

6.01 *Supervision and Superintendence*

A. Contractor shall supervise, inspect, and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Contract Documents. Contractor shall be solely responsible for the means, methods, techniques, sequences, and procedures of construction. Contractor shall not be responsible for the negligence of Owner or Engineer in the design or specification of a specific means, method, technique, sequence, or procedure of construction which is shown or indicated in and expressly required by the Contract Documents.

B. At all times during the progress of the Work, Contractor shall assign a competent resident superintendent who shall not be replaced without written notice to Owner and Engineer except under extraordinary circumstances.

6.02 *Labor; Working Hours*

A. Contractor shall provide competent, suitably qualified personnel to survey and lay out the Work and perform construction as required by the Contract Documents. Contractor shall at all times maintain good discipline and order at the Site.

B. Except as otherwise required for the safety or protection of persons or the Work or property at the Site or adjacent thereto, and except as otherwise stated in the Contract Documents, all Work at the Site shall be performed during regular working hours. Contractor will not permit the performance of Work on a Saturday, Sunday, or any legal holiday without Owner's written consent (which will not be unreasonably withheld) given after prior written notice to Engineer.

6.03 *Services, Materials, and Equipment*

A. Unless otherwise specified in the Contract Documents, Contractor shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities, temporary facilities, and all other facilities and incidentals necessary for the performance, testing, start-up, and completion of the Work.

B. All materials and equipment incorporated into the Work shall be as specified or, if not specified, shall be of good quality and new, except as otherwise provided in the Contract Documents. All special warranties and guarantees required by the Specifications shall expressly run to the benefit of Owner. If required by Engineer, Contractor shall furnish satisfactory evidence (including reports of required tests) as to the source, kind, and quality of materials and equipment.

C. All materials and equipment shall be stored, applied, installed, connected, erected, protected, used, cleaned, and conditioned in accordance with instructions of the applicable Supplier, except as otherwise may be provided in the Contract Documents.

6.04 *Progress Schedule*

A. Contractor shall adhere to the Progress Schedule established in accordance with Paragraph 2.07 as it may be adjusted from time to time as provided below.

1. Contractor shall submit to Engineer for acceptance (to the extent indicated in Paragraph 2.07) proposed adjustments in the Progress Schedule that will not result in changing the Contract Times. Such adjustments will comply with any provisions of the General Requirements applicable thereto.

2. Proposed adjustments in the Progress Schedule that will change the Contract Times shall be submitted in accordance with the requirements of Article 12. Adjustments in Contract Times may only be made by a Change Order.

6.05 *Substitutes and "Or-Equals"*

A. Whenever an item of material or equipment is specified or described in the Contract Documents by using the name of a proprietary item or the name of a particular Supplier, the specification or description is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or-equal" item or no substitution is permitted, other items of material or equipment or material or equipment of other Suppliers may be

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submitted to Engineer for review under the circumstances described below.

1. *"Or-Equal" Items:* If in Engineer's sole discretion an item of material or equipment proposed by Contractor is functionally equal to that named and sufficiently similar so that no change in related Work will be required, it may be considered by Engineer as an "or-equal" item, in which case review and approval of the proposed item may, in Engineer's sole discretion, be accomplished without compliance with some or all of the requirements for approval of proposed substitute items. For the purposes of this Paragraph 6.05.A.1, a proposed item of material or equipment will be considered functionally equal to an item so named if:

    a. in the exercise of reasonable judgment Engineer determines that:

        1) it is at least equal in materials of construction, quality, durability, appearance, strength, and design characteristics;

        2) it will reliably perform at least equally well the function and achieve the results imposed by the design concept of the completed Project as a functioning whole; and

        3) it has a proven record of performance and availability of responsive service.

    b. Contractor certifies that, if approved and incorporated into the Work:

        1) there will be no increase in cost to the Owner or increase in Contract Times; and

        2) it will conform substantially to the detailed requirements of the item named in the Contract Documents.

2. *Substitute Items:*

    a. If in Engineer's sole discretion an item of material or equipment proposed by Contractor does not qualify as an "or-equal" item under Paragraph 6.05.A.1, it will be considered a proposed substitute item.

    b. Contractor shall submit sufficient information as provided below to allow Engineer to determine if the item of material or equipment proposed is essentially equivalent to that named and an acceptable substitute therefor. Requests for review of proposed substitute items of material or equipment will not be accepted by Engineer from anyone other than Contractor.

    c. The requirements for review by Engineer will be as set forth in Paragraph 6.05.A.2.d, as supplemented by the General Requirements, and as Engineer may decide is appropriate under the circumstances.

    d. Contractor shall make written application to Engineer for review of a proposed substitute item of material or equipment that Contractor seeks to furnish or use. The application:

        1) shall certify that the proposed substitute item will:

            a) perform adequately the functions and achieve the results called for by the general design,

            b) be similar in substance to that specified, and

            c) be suited to the same use as that specified;

        2) will state:

            a) the extent, if any, to which the use of the proposed substitute item will prejudice Contractor's achievement of Substantial Completion on time,

            b) whether use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with Owner for other work on the Project) to adapt the design to the proposed substitute item, and

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c) whether incorporation or use of the proposed substitute item in connection with the Work is subject to payment of any license fee or royalty;

3) will identify:

a) all variations of the proposed substitute item from that specified, and

b) available engineering, sales, maintenance, repair, and replacement services; and

4) shall contain an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including costs of redesign and claims of other contractors affected by any resulting change.

B. *Substitute Construction Methods or Procedures:* If a specific means, method, technique, sequence, or procedure of construction is expressly required by the Contract Documents, Contractor may furnish or utilize a substitute means, method, technique, sequence, or procedure of construction approved by Engineer. Contractor shall submit sufficient information to allow Engineer, in Engineer's sole discretion, to determine that the substitute proposed is equivalent to that expressly called for by the Contract Documents. The requirements for review by Engineer will be similar to those provided in Paragraph 6.05.A.2.

C. *Engineer's Evaluation:* Engineer will be allowed a reasonable time within which to evaluate each proposal or submittal made pursuant to Paragraphs 6.05.A and 6.05.B. Engineer may require Contractor to furnish additional data about the proposed substitute item. Engineer will be the sole judge of acceptability. No "or equal" or substitute will be ordered, installed or utilized until Engineer's review is complete, which will be evidenced by a Change Order in the case of a substitute and an approved Shop Drawing for an "or equal." Engineer will advise Contractor in writing of any negative determination.

D. *Special Guarantee:* Owner may require Contractor to furnish at Contractor's expense a special performance guarantee or other surety with respect to any substitute.

E. *Engineer's Cost Reimbursement*: Engineer will record Engineer's costs in evaluating a substitute proposed or submitted by Contractor pursuant to Paragraphs 6.05.A.2 and 6.05.B. Whether or not Engineer approves a substitute so proposed or submitted by Contractor, Contractor shall reimburse Owner for the reasonable charges of Engineer for evaluating each such proposed substitute. Contractor shall also reimburse Owner for the reasonable charges of Engineer for making changes in the Contract Documents (or in the provisions of any other direct contract with Owner) resulting from the acceptance of each proposed substitute.

F. *Contractor's Expense*: Contractor shall provide all data in support of any proposed substitute or "or-equal" at Contractor's expense.

6.06 *Concerning Subcontractors, Suppliers, and Others*

A. Contractor shall not employ any Subcontractor, Supplier, or other individual or entity (including those acceptable to Owner as indicated in Paragraph 6.06.B), whether initially or as a replacement, against whom Owner may have reasonable objection. Contractor shall not be required to employ any Subcontractor, Supplier, or other individual or entity to furnish or perform any of the Work against whom Contractor has reasonable objection.

B. If the Supplementary Conditions require the identity of certain Subcontractors, Suppliers, or other individuals or entities to be submitted to Owner in advance for acceptance by Owner by a specified date prior to the Effective Date of the Agreement, and if Contractor has submitted a list thereof in accordance with the Supplementary Conditions, Owner's acceptance (either in writing or by failing to make written objection thereto by the date indicated for acceptance or objection in the Bidding Documents or the Contract Documents) of any such Subcontractor, Supplier, or other individual or entity so identified may be revoked on the basis of reasonable objection after due investigation. Contractor shall submit an acceptable replacement for the rejected Subcontractor, Supplier, or other individual or entity, and the Contract Price will be adjusted by the difference in the cost occasioned by such replacement, and an appropriate Change Order will be issued. No acceptance by Owner of any such Subcontractor, Supplier, or other individual or entity, whether initially or as a replacement,

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shall constitute a waiver of any right of Owner or Engineer to reject defective Work.

C. Contractor shall be fully responsible to Owner and Engineer for all acts and omissions of the Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work just as Contractor is responsible for Contractor's own acts and omissions. Nothing in the Contract Documents:

1. shall create for the benefit of any such Subcontractor, Supplier, or other individual or entity any contractual relationship between Owner or Engineer and any such Subcontractor, Supplier or other individual or entity; nor

2. shall create any obligation on the part of Owner or Engineer to pay or to see to the payment of any moneys due any such Subcontractor, Supplier, or other individual or entity except as may otherwise be required by Laws and Regulations.

D. Contractor shall be solely responsible for scheduling and coordinating the Work of Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work under a direct or indirect contract with Contractor.

E. Contractor shall require all Subcontractors, Suppliers, and such other individuals or entities performing or furnishing any of the Work to communicate with Engineer through Contractor.

F. The divisions and sections of the Specifications and the identifications of any Drawings shall not control Contractor in dividing the Work among Subcontractors or Suppliers or delineating the Work to be performed by any specific trade.

G. All Work performed for Contractor by a Subcontractor or Supplier will be pursuant to an appropriate agreement between Contractor and the Subcontractor or Supplier which specifically binds the Subcontractor or Supplier to the applicable terms and conditions of the Contract Documents for the benefit of Owner and Engineer. Whenever any such agreement is with a Subcontractor or Supplier who is listed as a loss payee on the property insurance provided in Paragraph 5.06, the agreement between the Contractor and the Subcontractor or Supplier will contain provisions whereby the Subcontractor or Supplier waives all rights against Owner, Contractor, Engineer, and all other individuals or entities identified in the Supplementary Conditions to be listed as insureds or loss payees (and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them) for all losses and damages caused by, arising out of, relating to, or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work. If the insurers on any such policies require separate waiver forms to be signed by any Subcontractor or Supplier, Contractor will obtain the same.

6.07 *Patent Fees and Royalties*

A. Contractor shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product, or device which is the subject of patent rights or copyrights held by others. If a particular invention, design, process, product, or device is specified in the Contract Documents for use in the performance of the Work and if, to the actual knowledge of Owner or Engineer, its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights shall be disclosed by Owner in the Contract Documents.

B. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, and its officers, directors, members, partners, employees, agents, consultants, and subcontractors from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device specified in the Contract Documents, but not identified as being subject to payment of any license fee or royalty to others required by patent rights or copyrights.

C. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses,

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and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device not specified in the Contract Documents.

6.08 *Permits*

A. Unless otherwise provided in the Supplementary Conditions, Contractor shall obtain and pay for all construction permits and licenses. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the Work which are applicable at the time of opening of Bids, or, if there are no Bids, on the Effective Date of the Agreement. Owner shall pay all charges of utility owners for connections for providing permanent service to the Work.

6.09 *Laws and Regulations*

A. Contractor shall give all notices required by and shall comply with all Laws and Regulations applicable to the performance of the Work. Except where otherwise expressly required by applicable Laws and Regulations, neither Owner nor Engineer shall be responsible for monitoring Contractor's compliance with any Laws or Regulations.

B. If Contractor performs any Work knowing or having reason to know that it is contrary to Laws or Regulations, Contractor shall bear all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such Work. However, it shall not be Contractor's responsibility to make certain that the Specifications and Drawings are in accordance with Laws and Regulations, but this shall not relieve Contractor of Contractor's obligations under Paragraph 3.03.

C. Changes in Laws or Regulations not known at the time of opening of Bids (or, on the Effective Date of the Agreement if there were no Bids) having an effect on the cost or time of performance of the Work shall be the subject of an adjustment in Contract Price or Contract Times. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment, a Claim may be made therefor as provided in Paragraph 10.05.

6.10 *Taxes*

A. Contractor shall pay all sales, consumer, use, and other similar taxes required to be paid by Contractor in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

6.11 *Use of Site and Other Areas*

A. *Limitation on Use of Site and Other Areas:*

1. Contractor shall confine construction equipment, the storage of materials and equipment, and the operations of workers to the Site and other areas permitted by Laws and Regulations, and shall not unreasonably encumber the Site and other areas with construction equipment or other materials or equipment. Contractor shall assume full responsibility for any damage to any such land or area, or to the owner or occupant thereof, or of any adjacent land or areas resulting from the performance of the Work.

2. Should any claim be made by any such owner or occupant because of the performance of the Work, Contractor shall promptly settle with such other party by negotiation or otherwise resolve the claim by arbitration or other dispute resolution proceeding or at law.

3. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any claim or action, legal or equitable, brought by any such owner or occupant against Owner, Engineer, or any other party indemnified hereunder to the extent caused by or based upon Contractor's performance of the Work.

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B. *Removal of Debris During Performance of the Work:* During the progress of the Work Contractor shall keep the Site and other areas free from accumulations of waste materials, rubbish, and other debris. Removal and disposal of such waste materials, rubbish, and other debris shall conform to applicable Laws and Regulations.

C. *Cleaning:* Prior to Substantial Completion of the Work Contractor shall clean the Site and the Work and make it ready for utilization by Owner. At the completion of the Work Contractor shall remove from the Site all tools, appliances, construction equipment and machinery, and surplus materials and shall restore to original condition all property not designated for alteration by the Contract Documents.

D. *Loading Structures:* Contractor shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall Contractor subject any part of the Work or adjacent property to stresses or pressures that will endanger it.

6.12 *Record Documents*

A. Contractor shall maintain in a safe place at the Site one record copy of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, and written interpretations and clarifications in good order and annotated to show changes made during construction. These record documents together with all approved Samples and a counterpart of all approved Shop Drawings will be available to Engineer for reference. Upon completion of the Work, these record documents, Samples, and Shop Drawings will be delivered to Engineer 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. Such responsibility does not relieve Subcontractors of their responsibility for the safety of persons or property in the performance of their work, nor for compliance with applicable safety Laws and Regulations. 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 on the Site or 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.

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 for such safety and protection. 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.

C. Contractor shall comply with the applicable requirements of Owner's safety programs, if any. The Supplementary Conditions identify any Owner's safety programs that are applicable to the Work.

D. Contractor shall inform Owner and Engineer of the specific requirements of Contractor's safety program with which Owner's and Engineer's employees and representatives must comply while at the Site.

E. 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 acts or omissions of Owner or Engineer 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

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entity directly or indirectly employed by any of them).

F. 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 Engineer has issued a notice to Owner and Contractor in accordance with Paragraph 14.07.B that the Work is acceptable (except as otherwise expressly provided in connection with Substantial Completion).

6.14 *Safety Representative*

A. Contractor shall designate a qualified and experienced safety representative at the Site whose duties and responsibilities shall be the prevention of accidents and the maintaining and supervising of safety precautions and programs.

6.15 *Hazard Communication Programs*

A. Contractor shall be responsible for coordinating any exchange of material safety data sheets or other hazard communication information required to be made available to or exchanged between or among employers at the Site in accordance with Laws or Regulations.

6.16 *Emergencies*

A. In emergencies affecting the safety or protection of persons or the Work or property at the Site or adjacent thereto, Contractor is obligated to act to prevent threatened damage, injury, or loss. Contractor shall give Engineer prompt written notice if Contractor believes that any significant changes in the Work or variations from the Contract Documents have been caused thereby or are required as a result thereof. If Engineer determines that a change in the Contract Documents is required because of the action taken by Contractor in response to such an emergency, a Work Change Directive or Change Order will be issued.

6.17 *Shop Drawings and Samples*

A. Contractor shall submit Shop Drawings and Samples to Engineer for review and approval in accordance with the accepted Schedule of Submittals (as required by Paragraph 2.07). Each submittal will be identified as Engineer may require.

1. *Shop Drawings:*

   a. Submit number of copies specified in the General Requirements.

   b. Data shown on the Shop Drawings will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Contractor proposes to provide and to enable Engineer to review the information for the limited purposes required by Paragraph 6.17.D.

2. *Samples:*

   a. Submit number of Samples specified in the Specifications.

   b. Clearly identify each Sample as to material, Supplier, pertinent data such as catalog numbers, the use for which intended and other data as Engineer may require to enable Engineer to review the submittal for the limited purposes required by Paragraph 6.17.D.

B. Where a Shop Drawing or Sample is required by the Contract Documents or the Schedule of Submittals, any related Work performed prior to Engineer's review and approval of the pertinent submittal will be at the sole expense and responsibility of Contractor.

C. *Submittal Procedures:*

1. Before submitting each Shop Drawing or Sample, Contractor shall have:

   a. reviewed and coordinated each Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents;

   b. determined and verified all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto;

   c. determined and verified the suitability of all materials offered with respect to the

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indicated application, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work; and

d. determined and verified all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto.

2. Each submittal shall bear a stamp or specific written certification that Contractor has satisfied Contractor's obligations under the Contract Documents with respect to Contractor's review and approval of that submittal.

3. With each submittal, Contractor shall give Engineer specific written notice of any variations that the Shop Drawing or Sample may have from the requirements of the Contract Documents. This notice shall be both a written communication separate from the Shop Drawings or Sample submittal; and, in addition, by a specific notation made on each Shop Drawing or Sample submitted to Engineer for review and approval of each such variation.

D. *Engineer's Review:*

1. Engineer will provide timely review of Shop Drawings and Samples in accordance with the Schedule of Submittals acceptable to Engineer. Engineer's review and approval will be only to determine if the items covered by the submittals will, after installation or incorporation in the Work, conform to the information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.

2. Engineer's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction (except where a particular means, method, technique, sequence, or procedure of construction is specifically and expressly called for by the Contract Documents) or to safety precautions or programs incident thereto. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

3. Engineer's review and approval shall not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has complied with the requirements of Paragraph 6.17.C.3 and Engineer has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample. Engineer's review and approval shall not relieve Contractor from responsibility for complying with the requirements of Paragraph 6.17.C.1.

E. *Resubmittal Procedures:*

1. Contractor shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit, as required, new Samples for review and approval. Contractor shall direct specific attention in writing to revisions other than the corrections called for by Engineer on previous submittals.

6.18 *Continuing the Work*

A. Contractor shall carry on the Work and adhere to the Progress Schedule during all disputes or disagreements with Owner. No Work shall be delayed or postponed pending resolution of any disputes or disagreements, except as permitted by Paragraph 15.04 or as Owner and Contractor may otherwise agree in writing.

6.19 *Contractor's General Warranty and Guarantee*

A. Contractor warrants and guarantees to Owner that all Work will be in accordance with the Contract Documents and will not be defective. Engineer and its officers, directors, members, partners, employees, agents, consultants, and subcontractors shall be entitled to rely on representation of Contractor's warranty and guarantee.

B. Contractor's warranty and guarantee hereunder excludes defects or damage caused by:

1. abuse, modification, or improper maintenance or operation by persons other than Contractor, Subcontractors, Suppliers, or any other

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individual or entity for whom Contractor is responsible; or

2. normal wear and tear under normal usage.

C. Contractor's obligation to perform and complete the Work in accordance with the Contract Documents shall be absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents or a release of Contractor's obligation to perform the Work in accordance with the Contract Documents:

1. observations by Engineer;

2. recommendation by Engineer or payment by Owner of any progress or final payment;

3. the issuance of a certificate of Substantial Completion by Engineer or any payment related thereto by Owner;

4. use or occupancy of the Work or any part thereof by Owner;

5. any review and approval of a Shop Drawing or Sample submittal or the issuance of a notice of acceptability by Engineer;

6. any inspection, test, or approval by others; or

7. any correction of defective Work by Owner.

6.20 *Indemnification*

A. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the performance of the Work, provided that any such claim, cost, loss, or damage is attributable to bodily injury, sickness, disease, or death, or to injury to or destruction of tangible property (other than the Work itself), including the loss of use resulting therefrom but only to the extent caused by any negligent act or omission of Contractor, any Subcontractor, any Supplier, or any 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 .

B. In any and all claims against Owner or Engineer or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors by any employee (or the survivor or personal representative of such employee) of Contractor, any Subcontractor, any Supplier, or any 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, the indemnification obligation under Paragraph 6.20.A shall not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for Contractor or any such Subcontractor, Supplier, or other individual or entity under workers' compensation acts, disability benefit acts, or other employee benefit acts.

C. The indemnification obligations of Contractor under Paragraph 6.20.A shall not extend to the liability of Engineer and Engineer's officers, directors, members, partners, employees, agents, consultants and subcontractors arising out of:

1. the preparation or approval of, or the failure to prepare or approve maps, Drawings, opinions, reports, surveys, Change Orders, designs, or Specifications; or

2. giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

6.21 *Delegation of Professional Design Services*

A. Contractor will not be required to provide professional design services unless such services are specifically required by the Contract Documents for a portion of the Work or unless such services are required to carry out Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. Contractor shall not be required to provide professional services in violation of applicable law.

B. If professional design services or certifications by a design professional related to systems, materials or equipment are specifically required of Contractor by the Contract Documents, Owner and Engineer will specify all performance and design criteria that such services must satisfy. Contractor shall cause such services or

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certifications to be provided by a properly licensed professional, whose signature and seal shall appear on all drawings, calculations, specifications, certifications, Shop Drawings and other submittals prepared by such professional. Shop Drawings and other submittals related to the Work designed or certified by such professional, if prepared by others, shall bear such professional's written approval when submitted to Engineer.

C. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy and completeness of the services, certifications or approvals performed by such design professionals, provided Owner and Engineer have specified to Contractor all performance and design criteria that such services must satisfy.

D. Pursuant to this Paragraph 6.21, Engineer's review and approval of design calculations and design drawings will be only for the limited purpose of checking for conformance with performance and design criteria given and the design concept expressed in the Contract Documents. Engineer's review and approval of Shop Drawings and other submittals (except design calculations and design drawings) will be only for the purpose stated in Paragraph 6.17.D.1.

E. Contractor shall not be responsible for the adequacy of the performance or design criteria required by the Contract Documents.

ARTICLE 7 – OTHER WORK AT THE SITE

7.01 *Related Work at Site*

A. Owner may perform other work related to the Project at the Site with Owner's employees, or through other direct contracts therefor, or have other work performed by utility owners. If such other work is not noted in the Contract Documents, then:

1. written notice thereof will be given to Contractor prior to starting any such other work; and

2. if Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times that should be allowed as a result of such other work, a Claim may be made therefor as provided in Paragraph 10.05.

B. Contractor shall afford each other contractor who is a party to such a direct contract, each utility owner, and Owner, if Owner is performing other work with Owner's employees, proper and safe access to the Site, provide a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such other work, and properly coordinate the Work with theirs. Contractor shall do all cutting, fitting, and patching of the Work that may be required to properly connect or otherwise make its several parts come together and properly integrate with such other work. Contractor shall not endanger any work of others by cutting, excavating, or otherwise altering such work; provided, however, that Contractor may cut or alter others' work with the written consent of Engineer and the others whose work will be affected. The duties and responsibilities of Contractor under this Paragraph are for the benefit of such utility owners and other contractors to the extent that there are comparable provisions for the benefit of Contractor in said direct contracts between Owner and such utility owners and other contractors.

C. If the proper execution or results of any part of Contractor's Work depends upon work performed by others under this Article 7, Contractor shall inspect such other work and promptly report to Engineer in writing any delays, defects, or deficiencies in such other work that render it unavailable or unsuitable for the proper execution and results of Contractor's Work. Contractor's failure to so report will constitute an acceptance of such other work as fit and proper for integration with Contractor's Work except for latent defects and deficiencies in such other work.

7.02 *Coordination*

A. If Owner intends to contract with others for the performance of other work on the Project at the Site, the following will be set forth in Supplementary Conditions:

1. the individual or entity who will have authority and responsibility for coordination of the activities among the various contractors will be identified;

2. the specific matters to be covered by such authority and responsibility will be itemized; and

3. the extent of such authority and responsibilities will be provided.

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B. Unless otherwise provided in the Supplementary Conditions, Owner shall have sole authority and responsibility for such coordination.

7.03 *Legal Relationships*

A. Paragraphs 7.01.A and 7.02 are not applicable for utilities not under the control of Owner.

B. Each other direct contract of Owner under Paragraph 7.01.A shall provide that the other contractor is liable to Owner and Contractor for the reasonable direct delay and disruption costs incurred by Contractor as a result of the other contractor's wrongful actions or inactions.

C. Contractor shall be liable to Owner and any other contractor under direct contract to Owner for the reasonable direct delay and disruption costs incurred by such other contractor as a result of Contractor's wrongful action or inactions.

ARTICLE 8 – OWNER'S RESPONSIBILITIES

8.01 *Communications to Contractor*

A. Except as otherwise provided in these General Conditions, Owner shall issue all communications to Contractor through Engineer.

8.02 *Replacement of Engineer*

A. In case of termination of the employment of Engineer, Owner shall appoint an engineer to whom Contractor makes no reasonable objection, whose status under the Contract Documents shall be that of the former Engineer.

8.03 *Furnish Data*

A. Owner shall promptly furnish the data required of Owner under the Contract Documents.

8.04 *Pay When Due*

A. Owner shall make payments to Contractor when they are due as provided in Paragraphs 14.02.C and 14.07.C.

8.05 *Lands and Easements; Reports and Tests*

A. Owner's duties with respect to providing lands and easements and providing engineering surveys to establish reference points are set forth in Paragraphs 4.01 and 4.05. Paragraph 4.02 refers to Owner's identifying and making available to Contractor copies of reports of explorations and tests of subsurface conditions and drawings of physical conditions relating to existing surface or subsurface structures at the Site.

8.06 *Insurance*

A. Owner's responsibilities, if any, with respect to purchasing and maintaining liability and property insurance are set forth in Article 5.

8.07 *Change Orders*

A. Owner is obligated to execute Change Orders as indicated in Paragraph 10.03.

8.08 *Inspections, Tests, and Approvals*

A. Owner's responsibility with respect to certain inspections, tests, and approvals is set forth in Paragraph 13.03.B.

8.09 *Limitations on Owner's Responsibilities*

A. The Owner shall not supervise, direct, or have control or authority over, nor be responsible for, Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Owner will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

8.10 *Undisclosed Hazardous Environmental Condition*

A. Owner's responsibility in respect to an undisclosed Hazardous Environmental Condition is set forth in Paragraph 4.06.

8.11 *Evidence of Financial Arrangements*

A. Upon request of Contractor, Owner shall furnish Contractor reasonable evidence that financial arrangements have been made to satisfy Owner's obligations under the Contract Documents.

8.12 *Compliance with Safety Program*

A. While at the Site, Owner's employees and representatives shall comply with the specific applicable requirements of Contractor's safety programs of which Owner has been informed pursuant to Paragraph 6.13.D.

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ARTICLE 9 – ENGINEER'S STATUS DURING CONSTRUCTION

9.01 *Owner's Representative*

A. Engineer will be Owner's representative during the construction period. The duties and responsibilities and the limitations of authority of Engineer as Owner's representative during construction are set forth in the Contract Documents.

9.02 *Visits to Site*

A. Engineer will make visits to the Site at intervals appropriate to the various stages of construction as Engineer deems necessary in order to observe as an experienced and qualified design professional the progress that has been made and the quality of the various aspects of Contractor's executed Work. Based on information obtained during such visits and observations, Engineer, for the benefit of Owner, will determine, in general, if the Work is proceeding in accordance with the Contract Documents. Engineer will not be required to make exhaustive or continuous inspections on the Site to check the quality or quantity of the Work. Engineer's efforts will be directed toward providing for Owner a greater degree of confidence that the completed Work will conform generally to the Contract Documents. On the basis of such visits and observations, Engineer will keep Owner informed of the progress of the Work and will endeavor to guard Owner against defective Work.

B. Engineer's visits and observations are subject to all the limitations on Engineer's authority and responsibility set forth in Paragraph 9.09. Particularly, but without limitation, during or as a result of Engineer's visits or observations of Contractor's Work, Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work.

9.03 *Project Representative*

A. If Owner and Engineer agree, Engineer will furnish a Resident Project Representative to assist Engineer in providing more extensive observation of the Work. The authority and responsibilities of any such Resident Project Representative and assistants will be as provided in the Supplementary Conditions, and limitations on the responsibilities thereof will be as provided in Paragraph 9.09. If Owner designates another representative or agent to represent Owner at the Site who is not Engineer's consultant, agent or employee, the responsibilities and authority and limitations thereon of such other individual or entity will be as provided in the Supplementary Conditions.

9.04 *Authorized Variations in Work*

A. Engineer may authorize minor variations in the Work from the requirements of the Contract Documents which do not involve an adjustment in the Contract Price or the Contract Times and are compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. These may be accomplished by a Field Order and will be binding on Owner and also on Contractor, who shall perform the Work involved promptly. If Owner or Contractor believes that a Field Order justifies an adjustment in the Contract Price or Contract Times, or both, and the parties are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment, a Claim may be made therefor as provided in Paragraph 10.05.

9.05 *Rejecting Defective Work*

A. Engineer will have authority to reject Work which Engineer believes to be defective, or that Engineer believes will not produce a completed Project that conforms to the Contract Documents or that will prejudice the integrity of the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. Engineer will also have authority to require special inspection or testing of the Work as provided in Paragraph 13.04, whether or not the Work is fabricated, installed, or completed.

9.06 *Shop Drawings, Change Orders and Payments*

A. In connection with Engineer's authority, and limitations thereof, as to Shop Drawings and Samples, see Paragraph 6.17.

B. In connection with Engineer's authority, and limitations thereof, as to design calculations and design drawings submitted in response to a

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delegation of professional design services, if any, see Paragraph 6.21.

C. In connection with Engineer's authority as to Change Orders, see Articles 10, 11, and 12.

D. In connection with Engineer's authority as to Applications for Payment, see Article 14.

9.07 *Determinations for Unit Price Work*

A. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor. Engineer will review with Contractor the Engineer's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). Engineer's written decision thereon will be final and binding (except as modified by Engineer to reflect changed factual conditions or more accurate data) upon Owner and Contractor, subject to the provisions of Paragraph 10.05.

9.08 *Decisions on Requirements of Contract Documents and Acceptability of Work*

A. Engineer will be the initial interpreter of the requirements of the Contract Documents and judge of the acceptability of the Work thereunder. All matters in question and other matters between Owner and Contractor arising prior to the date final payment is due relating to the acceptability of the Work, and the interpretation of the requirements of the Contract Documents pertaining to the performance of the Work, will be referred initially to Engineer in writing within 30 days of the event giving rise to the question.

B. Engineer will, with reasonable promptness, render a written decision on the issue referred. If Owner or Contractor believes that any such decision entitles them to an adjustment in the Contract Price or Contract Times or both, a Claim may be made under Paragraph 10.05. The date of Engineer's decision shall be the date of the event giving rise to the issues referenced for the purposes of Paragraph 10.05.B.

C. Engineer's written decision on the issue referred will be final and binding on Owner and Contractor, subject to the provisions of Paragraph 10.05.

D. When functioning as interpreter and judge under this Paragraph 9.08, Engineer will not show partiality to Owner or Contractor and will not be liable in connection with any interpretation or decision rendered in good faith in such capacity.

9.09 *Limitations on Engineer's Authority and Responsibilities*

A. Neither Engineer's authority or responsibility under this Article 9 or under any other provision of the Contract Documents nor any decision made by Engineer in good faith either to exercise or not exercise such authority or responsibility or the undertaking, exercise, or performance of any authority or responsibility by Engineer shall create, impose, or give rise to any duty in contract, tort, or otherwise owed by Engineer to Contractor, any Subcontractor, any Supplier, any other individual or entity, or to any surety for or employee or agent of any of them.

B. Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Engineer will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

C. Engineer will not be responsible for the acts or omissions of Contractor or of any Subcontractor, any Supplier, or of any other individual or entity performing any of the Work.

D. Engineer's review of the final Application for Payment and accompanying documentation and all maintenance and operating instructions, schedules, guarantees, bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered by Paragraph 14.07.A will only be to determine generally that their content complies with the requirements of, and in the case of certificates of inspections, tests, and approvals that the results certified indicate compliance with, the Contract Documents.

E. The limitations upon authority and responsibility set forth in this Paragraph 9.09 shall also apply to the Resident Project Representative, if any, and assistants, if any.

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9.10 *Compliance with Safety Program*

A. While at the Site, Engineer's employees and representatives shall comply with the specific applicable requirements of Contractor's safety programs of which Engineer has been informed pursuant to Paragraph 6.13.D.

ARTICLE 10 – CHANGES IN THE WORK; CLAIMS

10.01 *Authorized Changes in the Work*

A. Without invalidating the Contract and without notice to any surety, Owner may, at any time or from time to time, order additions, deletions, or revisions in the Work by a Change Order, or a Work Change Directive. Upon receipt of any such document, Contractor shall promptly proceed with the Work involved which will be performed under the applicable conditions of the Contract Documents (except as otherwise specifically provided).

B. If Owner and Contractor are unable to agree on entitlement to, or on the amount or extent, if any, of an adjustment in the Contract Price or Contract Times, or both, that should be allowed as a result of a Work Change Directive, a Claim may be made therefor as provided in Paragraph 10.05.

10.02 *Unauthorized Changes in the Work*

A. Contractor shall not be entitled to an increase in the Contract Price or an extension of the Contract Times with respect to any work performed that is not required by the Contract Documents as amended, modified, or supplemented as provided in Paragraph 3.04, except in the case of an emergency as provided in Paragraph 6.16 or in the case of uncovering Work as provided in Paragraph 13.04.D.

10.03 *Execution of Change Orders*

A. Owner and Contractor shall execute appropriate Change Orders recommended by Engineer covering:

1. changes in the Work which are: (i) ordered by Owner pursuant to Paragraph 10.01.A, (ii) required because of acceptance of defective Work under Paragraph 13.08.A or Owner's correction of defective Work under Paragraph 13.09, or (iii) agreed to by the parties;

2. changes in the Contract Price or Contract Times which are agreed to by the parties, including any undisputed sum or amount of time for Work actually performed in accordance with a Work Change Directive; and

3. changes in the Contract Price or Contract Times which embody the substance of any written decision rendered by Engineer pursuant to Paragraph 10.05; provided that, in lieu of executing any such Change Order, an appeal may be taken from any such decision in accordance with the provisions of the Contract Documents and applicable Laws and Regulations, but during any such appeal, Contractor shall carry on the Work and adhere to the Progress Schedule as provided in Paragraph 6.18.A.

10.04 *Notification to Surety*

A. If the provisions of any bond require notice to be given to a surety of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Times), the giving of any such notice will be Contractor's responsibility. The amount of each applicable bond will be adjusted to reflect the effect of any such change.

10.05 *Claims*

A. *Engineer's Decision Required*: All Claims, except those waived pursuant to Paragraph 14.09, shall be referred to the Engineer for decision. A decision by Engineer shall be required as a condition precedent to any exercise by Owner or Contractor of any rights or remedies either may otherwise have under the Contract Documents or by Laws and Regulations in respect of such Claims.

B. *Notice:* Written notice stating the general nature of each Claim shall be delivered by the claimant to Engineer and the other party to the Contract promptly (but in no event later than 30 days) after the start of the event giving rise thereto. The responsibility to substantiate a Claim shall rest with the party making the Claim. Notice of the amount or extent of the Claim, with supporting data shall be delivered to the Engineer and the other party to the Contract within 60 days after the start of such event (unless Engineer allows additional time for claimant to submit additional

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or more accurate data in support of such Claim). A Claim for an adjustment in Contract Price shall be prepared in accordance with the provisions of Paragraph 12.01.B. A Claim for an adjustment in Contract Times shall be prepared in accordance with the provisions of Paragraph 12.02.B. Each Claim shall be accompanied by claimant's written statement that the adjustment claimed is the entire adjustment to which the claimant believes it is entitled as a result of said event. The opposing party shall submit any response to Engineer and the claimant within 30 days after receipt of the claimant's last submittal (unless Engineer allows additional time).

C. *Engineer's Action*: Engineer will review each Claim and, within 30 days after receipt of the last submittal of the claimant or the last submittal of the opposing party, if any, take one of the following actions in writing:

1. deny the Claim in whole or in part;

2. approve the Claim; or

3. notify the parties that the Engineer is unable to resolve the Claim if, in the Engineer's sole discretion, it would be inappropriate for the Engineer to do so. For purposes of further resolution of the Claim, such notice shall be deemed a denial.

D. In the event that Engineer does not take action on a Claim within said 30 days, the Claim shall be deemed denied.

E. Engineer's written action under Paragraph 10.05.C or denial pursuant to Paragraphs 10.05.C.3 or 10.05.D will be final and binding upon Owner and Contractor, unless Owner or Contractor invoke the dispute resolution procedure set forth in Article 16 within 30 days of such action or denial.

F. No Claim for an adjustment in Contract Price or Contract Times will be valid if not submitted in accordance with this Paragraph 10.05.

ARTICLE 11 – COST OF THE WORK; ALLOWANCES; UNIT PRICE WORK

11.01 *Cost of the Work*

A. *Costs Included:* The term Cost of the Work means the sum of all costs, except those excluded in Paragraph 11.01.B, necessarily incurred and paid by Contractor in the proper performance of the Work. When the value of any Work covered by a Change Order or when a Claim for an adjustment in Contract Price is determined on the basis of Cost of the Work, the costs to be reimbursed to Contractor will be only those additional or incremental costs required because of the change in the Work or because of the event giving rise to the Claim. Except as otherwise may be agreed to in writing by Owner, such costs shall be in amounts no higher than those prevailing in the locality of the Project, shall not include any of the costs itemized in Paragraph 11.01.B, and shall include only the following items:

1. Payroll costs for employees in the direct employ of Contractor in the performance of the Work under schedules of job classifications agreed upon by Owner and Contractor. Such employees shall include, without limitation, superintendents, foremen, and other personnel employed full time on the Work. Payroll costs for employees not employed full time on the Work shall be apportioned on the basis of their time spent on the Work. Payroll costs shall include, but not be limited to, salaries and wages plus the cost of fringe benefits, which shall include social security contributions, unemployment, excise, and payroll taxes, workers' compensation, health and retirement benefits, bonuses, sick leave, vacation and holiday pay applicable thereto. The expenses of performing Work outside of regular working hours, on Saturday, Sunday, or legal holidays, shall be included in the above to the extent authorized by Owner.

2. Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts shall accrue to Contractor unless Owner deposits funds with Contractor with which to make payments, in which case the cash discounts shall accrue to Owner. All trade discounts, rebates and refunds and returns from sale of surplus materials and equipment shall accrue to Owner, and Contractor shall make provisions so that they may be obtained.

3. Payments made by Contractor to Subcontractors for Work performed by Subcontractors. If required by Owner, Contractor shall obtain competitive bids from

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subcontractors acceptable to Owner and Contractor and shall deliver such bids to Owner, who will then determine, with the advice of Engineer, which bids, if any, will be acceptable. If any subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work plus a fee, the Subcontractor's Cost of the Work and fee shall be determined in the same manner as Contractor's Cost of the Work and fee as provided in this Paragraph 11.01.

4. Costs of special consultants (including but not limited to engineers, architects, testing laboratories, surveyors, attorneys, and accountants) employed for services specifically related to the Work.

5. Supplemental costs including the following:

    a. The proportion of necessary transportation, travel, and subsistence expenses of Contractor's employees incurred in discharge of duties connected with the Work.

    b. Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office, and temporary facilities at the Site, and hand tools not owned by the workers, which are consumed in the performance of the Work, and cost, less market value, of such items used but not consumed which remain the property of Contractor.

    c. Rentals of all construction equipment and machinery, and the parts thereof whether rented from Contractor or others in accordance with rental agreements approved by Owner with the advice of Engineer, and the costs of transportation, loading, unloading, assembly, dismantling, and removal thereof. All such costs shall be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts shall cease when the use thereof is no longer necessary for the Work.

    d. Sales, consumer, use, and other similar taxes related to the Work, and for which Contractor is liable, as imposed by Laws and Regulations.

    e. Deposits lost for causes other than negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

    f. Losses and damages (and related expenses) caused by damage to the Work, not compensated by insurance or otherwise, sustained by Contractor in connection with the performance of the Work (except losses and damages within the deductible amounts of property insurance established in accordance with Paragraph 5.06.D), provided such losses and damages have resulted from causes other than the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses shall include settlements made with the written consent and approval of Owner. No such losses, damages, and expenses shall be included in the Cost of the Work for the purpose of determining Contractor's fee.

    g. The cost of utilities, fuel, and sanitary facilities at the Site.

    h. Minor expenses such as telegrams, long distance telephone calls, telephone service at the Site, express and courier services, and similar petty cash items in connection with the Work.

    i. The costs of premiums for all bonds and insurance Contractor is required by the Contract Documents to purchase and maintain.

B. *Costs Excluded:* The term Cost of the Work shall not include any of the following items:

    1. Payroll costs and other compensation of Contractor's officers, executives, principals (of partnerships and sole proprietorships), general managers, safety managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expediters, timekeepers, clerks, and other personnel employed by Contractor, whether at the Site or in Contractor's principal or branch office for

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general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in Paragraph 11.01.A.1 or specifically covered by Paragraph 11.01.A.4, all of which are to be considered administrative costs covered by the Contractor's fee.

2. Expenses of Contractor's principal and branch offices other than Contractor's office at the Site.

3. Any part of Contractor's capital expenses, including interest on Contractor's capital employed for the Work and charges against Contractor for delinquent payments.

4. Costs due to the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied, and making good any damage to property.

5. Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in Paragraphs 11.01.A.

C. *Contractor's Fee:* When all the Work is performed on the basis of cost-plus, Contractor's fee shall be determined as set forth in the Agreement. When the value of any Work covered by a Change Order or when a Claim for an adjustment in Contract Price is determined on the basis of Cost of the Work, Contractor's fee shall be determined as set forth in Paragraph 12.01.C.

D. *Documentation:* Whenever the Cost of the Work for any purpose is to be determined pursuant to Paragraphs 11.01.A and 11.01.B, Contractor will establish and maintain records thereof in accordance with generally accepted accounting practices and submit in a form acceptable to Engineer an itemized cost breakdown together with supporting data.

11.02 *Allowances*

A. It is understood that Contractor has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be performed for such sums and by such persons or entities as may be acceptable to Owner and Engineer.

B. *Cash Allowances:*

1. Contractor agrees that:

a. the cash allowances include the cost to Contractor (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the Site, and all applicable taxes; and

b. Contractor's costs for unloading and handling on the Site, labor, installation, overhead, profit, and other expenses contemplated for the cash allowances have been included in the Contract Price and not in the allowances, and no demand for additional payment on account of any of the foregoing will be valid.

C. *Contingency Allowance:*

1. Contractor agrees that a contingency allowance, if any, is for the sole use of Owner to cover unanticipated costs.

D. Prior to final payment, an appropriate Change Order will be issued as recommended by Engineer to reflect actual amounts due Contractor on account of Work covered by allowances, and the Contract Price shall be correspondingly adjusted.

11.03 *Unit Price Work*

A. Where the Contract Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the unit price for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Agreement.

B. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Determinations of the actual quantities and classifications of Unit Price Work performed by Contractor will be made by Engineer subject to the provisions of Paragraph 9.07.

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C. Each unit price will be deemed to include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

D. Owner or Contractor may make a Claim for an adjustment in the Contract Price in accordance with Paragraph 10.05 if:

1. the quantity of any item of Unit Price Work performed by Contractor differs materially and significantly from the estimated quantity of such item indicated in the Agreement; and

2. there is no corresponding adjustment with respect to any other item of Work; and

3. Contractor believes that Contractor is entitled to an increase in Contract Price as a result of having incurred additional expense or Owner believes that Owner is entitled to a decrease in Contract Price and the parties are unable to agree as to the amount of any such increase or decrease.

ARTICLE 12 – CHANGE OF CONTRACT PRICE; CHANGE OF CONTRACT TIMES

12.01 *Change of Contract Price*

A. The Contract Price may only be changed by a Change Order. Any Claim for an adjustment in the Contract Price shall be based on written notice submitted by the party making the Claim to the Engineer and the other party to the Contract in accordance with the provisions of Paragraph 10.05.

B. The value of any Work covered by a Change Order or of any Claim for an adjustment in the Contract Price will be determined as follows:

1. where the Work involved is covered by unit prices contained in the Contract Documents, by application of such unit prices to the quantities of the items involved (subject to the provisions of Paragraph 11.03); or

2. where the Work involved is not covered by unit prices contained in the Contract Documents, by a mutually agreed lump sum (which may include an allowance for overhead and profit not necessarily in accordance with Paragraph 12.01.C.2); or

3. where the Work involved is not covered by unit prices contained in the Contract Documents and agreement to a lump sum is not reached under Paragraph 12.01.B.2, on the basis of the Cost of the Work (determined as provided in Paragraph 11.01) plus a Contractor's fee for overhead and profit (determined as provided in Paragraph 12.01.C).

C. *Contractor's Fee:* The Contractor's fee for overhead and profit shall be determined as follows:

1. a mutually acceptable fixed fee; or

2. if a fixed fee is not agreed upon, then a fee based on the following percentages of the various portions of the Cost of the Work:

a. for costs incurred under Paragraphs 11.01.A.1 and 11.01.A.2, the Contractor's fee shall be 15 percent;

b. for costs incurred under Paragraph 11.01.A.3, the Contractor's fee shall be five percent;

c. where one or more tiers of subcontracts are on the basis of Cost of the Work plus a fee and no fixed fee is agreed upon, the intent of Paragraphs 12.01.C.2.a and 12.01.C.2.b is that the Subcontractor who actually performs the Work, at whatever tier, will be paid a fee of 15 percent of the costs incurred by such Subcontractor under Paragraphs 11.01.A.1 and 11.01.A.2 and that any higher tier Subcontractor and Contractor will each be paid a fee of five percent of the amount paid to the next lower tier Subcontractor;

d. no fee shall be payable on the basis of costs itemized under Paragraphs 11.01.A.4, 11.01.A.5, and 11.01.B;

e. the amount of credit to be allowed by Contractor to Owner for any change which results in a net decrease in cost will be the amount of the actual net decrease in cost plus a deduction in Contractor's fee by an amount equal to five percent of such net decrease; and

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f. when both additions and credits are involved in any one change, the adjustment in Contractor's fee shall be computed on the basis of the net change in accordance with Paragraphs 12.01.C.2.a through 12.01.C.2.e, inclusive.

12.02 *Change of Contract Times*

A. The Contract Times may only be changed by a Change Order. Any Claim for an adjustment in the Contract Times shall be based on written notice submitted by the party making the Claim to the Engineer and the other party to the Contract in accordance with the provisions of Paragraph 10.05.

B. Any adjustment of the Contract Times covered by a Change Order or any Claim for an adjustment in the Contract Times will be determined in accordance with the provisions of this Article 12.

12.03 *Delays*

A. Where Contractor is prevented from completing any part of the Work within the Contract Times due to delay beyond the control of Contractor, the Contract Times will be extended in an amount equal to the time lost due to such delay if a Claim is made therefor as provided in Paragraph 12.02.A. Delays beyond the control of Contractor shall include, but not be limited to, acts or neglect by Owner, acts or neglect of utility owners or other contractors performing other work as contemplated by Article 7, fires, floods, epidemics, abnormal weather conditions, or acts of God.

B. If Owner, Engineer, or other contractors or utility owners performing other work for Owner as contemplated by Article 7, or anyone for whom Owner is responsible, delays, disrupts, or interferes with the performance or progress of the Work, then Contractor shall be entitled to an equitable adjustment in the Contract Price or the Contract Times, or both. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times.

C. If Contractor is delayed in the performance or progress of the Work by fire, flood, epidemic, abnormal weather conditions, acts of God, acts or failures to act of utility owners not under the control of Owner, or other causes not the fault of and beyond control of Owner and Contractor, then Contractor shall be entitled to an equitable adjustment in Contract Times, if such adjustment is essential to Contractor's ability to complete the Work within the Contract Times. Such an adjustment shall be Contractor's sole and exclusive remedy for the delays described in this Paragraph 12.03.C.

D. Owner, Engineer, and their officers, directors, members, partners, employees, agents, consultants, or subcontractors shall not be liable to Contractor for any claims, costs, losses, or damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by Contractor on or in connection with any other project or anticipated project.

E. Contractor shall not be entitled to an adjustment in Contract Price or Contract Times for delays within the control of Contractor. Delays attributable to and within the control of a Subcontractor or Supplier shall be deemed to be delays within the control of Contractor.

ARTICLE 13 – TESTS AND INSPECTIONS; CORRECTION, REMOVAL OR ACCEPTANCE OF DEFECTIVE WORK

13.01 *Notice of Defects*

A. Prompt notice of all defective Work of which Owner or Engineer has actual knowledge will be given to Contractor. Defective Work may be rejected, corrected, or accepted as provided in this Article 13.

13.02 *Access to Work*

A. Owner, Engineer, their consultants and other representatives and personnel of Owner, independent testing laboratories, and governmental agencies with jurisdictional interests will have access to the Site and the Work at reasonable times for their observation, inspection, and testing. Contractor shall provide them proper and safe conditions for such access and advise them of Contractor's safety procedures and programs so that they may comply therewith as applicable.

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13.03 *Tests and Inspections*

A. Contractor shall give Engineer timely notice of readiness of the Work for all required inspections, tests, or approvals and shall cooperate with inspection and testing personnel to facilitate required inspections or tests.

B. Owner shall employ and pay for the services of an independent testing laboratory to perform all inspections, tests, or approvals required by the Contract Documents except:

1. for inspections, tests, or approvals covered by Paragraphs 13.03.C and 13.03.D below;

2. that costs incurred in connection with tests or inspections conducted pursuant to Paragraph 13.04.B shall be paid as provided in Paragraph 13.04.C; and

3. as otherwise specifically provided in the Contract Documents.

C. If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) specifically to be inspected, tested, or approved by an employee or other representative of such public body, Contractor shall assume full responsibility for arranging and obtaining such inspections, tests, or approvals, pay all costs in connection therewith, and furnish Engineer the required certificates of inspection or approval.

D. Contractor shall be responsible for arranging and obtaining and shall pay all costs in connection with any inspections, tests, or approvals required for Owner's and Engineer's acceptance of materials or equipment to be incorporated in the Work; or acceptance of materials, mix designs, or equipment submitted for approval prior to Contractor's purchase thereof for incorporation in the Work. Such inspections, tests, or approvals shall be performed by organizations acceptable to Owner and Engineer.

E. If any Work (or the work of others) that is to be inspected, tested, or approved is covered by Contractor without written concurrence of Engineer, Contractor shall, if requested by Engineer, uncover such Work for observation.

F. Uncovering Work as provided in Paragraph 13.03.E shall be at Contractor's expense unless Contractor has given Engineer timely notice of Contractor's intention to cover the same and Engineer has not acted with reasonable promptness in response to such notice.

13.04 *Uncovering Work*

A. If any Work is covered contrary to the written request of Engineer, it must, if requested by Engineer, be uncovered for Engineer's observation and replaced at Contractor's expense.

B. If Engineer considers it necessary or advisable that covered Work be observed by Engineer or inspected or tested by others, Contractor, at Engineer's request, shall uncover, expose, or otherwise make available for observation, inspection, or testing as Engineer may require, that portion of the Work in question, furnishing all necessary labor, material, and equipment.

C. If it is found that the uncovered Work is defective, Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such uncovering, exposure, observation, inspection, and testing, and of satisfactory replacement or reconstruction (including but not limited to all costs of repair or replacement of work of others); and Owner shall be entitled to an appropriate decrease in the Contract Price. If the parties are unable to agree as to the amount thereof, Owner may make a Claim therefor as provided in Paragraph 10.05.

D. If the uncovered Work is not found to be defective, Contractor shall be allowed an increase in the Contract Price or an extension of the Contract Times, or both, directly attributable to such uncovering, exposure, observation, inspection, testing, replacement, and reconstruction. If the parties are unable to agree as to the amount or extent thereof, Contractor may make a Claim therefor as provided in Paragraph 10.05.

13.05 *Owner May Stop the Work*

A. If the Work is defective, or Contractor fails to supply sufficient skilled workers or suitable materials or equipment, or fails to perform the Work in such a way that the completed Work will conform to the Contract Documents, Owner may order Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of Owner to stop

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the Work shall not give rise to any duty on the part of Owner to exercise this right for the benefit of Contractor, any Subcontractor, any Supplier, any other individual or entity, or any surety for, or employee or agent of any of them.

13.06 *Correction or Removal of Defective Work*

A. Promptly after receipt of written notice, Contractor shall correct all defective Work, whether or not fabricated, installed, or completed, or, if the Work has been rejected by Engineer, remove it from the Project and replace it with Work that is not defective. Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or removal (including but not limited to all costs of repair or replacement of work of others).

B. When correcting defective Work under the terms of this Paragraph 13.06 or Paragraph 13.07, Contractor shall take no action that would void or otherwise impair Owner's special warranty and guarantee, if any, on said Work.

13.07 *Correction Period*

A. If within one year after the date of Substantial Completion (or such longer period of time as may be prescribed by the terms of any applicable special guarantee required by the Contract Documents) or by any specific provision of the Contract Documents, any Work is found to be defective, or if the repair of any damages to the land or areas made available for Contractor's use by Owner or permitted by Laws and Regulations as contemplated in Paragraph 6.11.A is found to be defective, Contractor shall promptly, without cost to Owner and in accordance with Owner's written instructions:

1. repair such defective land or areas; or

2. correct such defective Work; or

3. if the defective Work has been rejected by Owner, remove it from the Project and replace it with Work that is not defective, and

4. satisfactorily correct or repair or remove and replace any damage to other Work, to the work of others or other land or areas resulting therefrom.

B. If Contractor does not promptly comply with the terms of Owner's written instructions, or in an emergency where delay would cause serious risk of loss or damage, Owner may have the defective Work corrected or repaired or may have the rejected Work removed and replaced. All claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or repair or such removal and replacement (including but not limited to all costs of repair or replacement of work of others) will be paid by Contractor.

C. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all the Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications.

D. Where defective Work (and damage to other Work resulting therefrom) has been corrected or removed and replaced under this Paragraph 13.07, the correction period hereunder with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactorily completed.

E. Contractor's obligations under this Paragraph 13.07 are in addition to any other obligation or warranty. The provisions of this Paragraph 13.07 shall not be construed as a substitute for, or a waiver of, the provisions of any applicable statute of limitation or repose.

13.08 *Acceptance of Defective Work*

A. If, instead of requiring correction or removal and replacement of defective Work, Owner (and, prior to Engineer's recommendation of final payment, Engineer) prefers to accept it, Owner may do so. Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) attributable to Owner's evaluation of and determination to accept such defective Work (such costs to be approved by Engineer as to reasonableness) and for the diminished value of the Work to the extent not otherwise paid by Contractor pursuant to this sentence. If any such acceptance occurs prior to

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Engineer's recommendation of final payment, a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work, and Owner shall be entitled to an appropriate decrease in the Contract Price, reflecting the diminished value of Work so accepted. If the parties are unable to agree as to the amount thereof, Owner may make a Claim therefor as provided in Paragraph 10.05. If the acceptance occurs after such recommendation, an appropriate amount will be paid by Contractor to Owner.

13.09 *Owner May Correct Defective Work*

A. If Contractor fails within a reasonable time after written notice from Engineer to correct defective Work, or to remove and replace rejected Work as required by Engineer in accordance with Paragraph 13.06.A, or if Contractor fails to perform the Work in accordance with the Contract Documents, or if Contractor fails to comply with any other provision of the Contract Documents, Owner may, after seven days written notice to Contractor, correct, or remedy any such deficiency.

B. In exercising the rights and remedies under this Paragraph 13.09, Owner shall proceed expeditiously. In connection with such corrective or remedial action, Owner may exclude Contractor from all or part of the Site, take possession of all or part of the Work and suspend Contractor's services related thereto, take possession of Contractor's tools, appliances, construction equipment and machinery at the Site, and incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere. Contractor shall allow Owner, Owner's representatives, agents and employees, Owner's other contractors, and Engineer and Engineer's consultants access to the Site to enable Owner to exercise the rights and remedies under this Paragraph.

C. All claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) incurred or sustained by Owner in exercising the rights and remedies under this Paragraph 13.09 will be charged against Contractor, and a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work; and Owner shall be entitled to an appropriate decrease in the Contract Price. If the parties are unable to agree as to the amount of the adjustment, Owner may make a Claim therefor as provided in Paragraph 10.05. Such claims, costs, losses and damages will include but not be limited to all costs of repair, or replacement of work of others destroyed or damaged by correction, removal, or replacement of Contractor's defective Work.

D. Contractor shall not be allowed an extension of the Contract Times because of any delay in the performance of the Work attributable to the exercise by Owner of Owner's rights and remedies under this Paragraph 13.09.

ARTICLE 14 – PAYMENTS TO CONTRACTOR AND COMPLETION

14.01 *Schedule of Values*

A. The Schedule of Values established as provided in Paragraph 2.07.A will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to Engineer. Progress payments on account of Unit Price Work will be based on the number of units completed.

14.02 *Progress Payments*

A. *Applications for Payments:*

1. At least 20 days before the date established in the Agreement for each progress payment (but not more often than once a month), Contractor shall submit to Engineer for review an Application for Payment filled out and signed by Contractor covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing, the Application for Payment shall also be accompanied by a bill of sale, invoice, or other documentation warranting that Owner has received the materials and equipment free and clear of all Liens and evidence that the materials and equipment are covered by appropriate property insurance or other arrangements to

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protect Owner's interest therein, all of which must be satisfactory to Owner.

2. Beginning with the second Application for Payment, each Application shall include an affidavit of Contractor stating that all previous progress payments received on account of the Work have been applied on account to discharge Contractor's legitimate obligations associated with prior Applications for Payment.

3. The amount of retainage with respect to progress payments will be as stipulated in the Agreement.

B. *Review of Applications:*

1. Engineer will, within 10 days after receipt of each Application for Payment, either indicate in writing a recommendation of payment and present the Application to Owner or return the Application to Contractor indicating in writing Engineer's reasons for refusing to recommend payment. In the latter case, Contractor may make the necessary corrections and resubmit the Application.

2. Engineer's recommendation of any payment requested in an Application for Payment will constitute a representation by Engineer to Owner, based on Engineer's observations of the executed Work as an experienced and qualified design professional, and on Engineer's review of the Application for Payment and the accompanying data and schedules, that to the best of Engineer's knowledge, information and belief:

   a. the Work has progressed to the point indicated;

   b. the quality of the Work is generally in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Completion, the results of any subsequent tests called for in the Contract Documents, a final determination of quantities and classifications for Unit Price Work under Paragraph 9.07, and any other qualifications stated in the recommendation); and

   c. the conditions precedent to Contractor's being entitled to such payment appear to have been fulfilled in so far as it is Engineer's responsibility to observe the Work.

3. By recommending any such payment Engineer will not thereby be deemed to have represented that:

   a. inspections made to check the quality or the quantity of the Work as it has been performed have been exhaustive, extended to every aspect of the Work in progress, or involved detailed inspections of the Work beyond the responsibilities specifically assigned to Engineer in the Contract Documents; or

   b. there may not be other matters or issues between the parties that might entitle Contractor to be paid additionally by Owner or entitle Owner to withhold payment to Contractor.

4. Neither Engineer's review of Contractor's Work for the purposes of recommending payments nor Engineer's recommendation of any payment, including final payment, will impose responsibility on Engineer:

   a. to supervise, direct, or control the Work, or

   b. for the means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or

   c. for Contractor's failure to comply with Laws and Regulations applicable to Contractor's performance of the Work, or

   d. to make any examination to ascertain how or for what purposes Contractor has used the moneys paid on account of the Contract Price, or

   e. to determine that title to any of the Work, materials, or equipment has passed to Owner free and clear of any Liens.

5. Engineer may refuse to recommend the whole or any part of any payment if, in Engineer's opinion, it would be incorrect to make the

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representations to Owner stated in Paragraph 14.02.B.2. Engineer may also refuse to recommend any such payment or, because of subsequently discovered evidence or the results of subsequent inspections or tests, revise or revoke any such payment recommendation previously made, to such extent as may be necessary in Engineer's opinion to protect Owner from loss because:

a. the Work is defective, or completed Work has been damaged, requiring correction or replacement;

b. the Contract Price has been reduced by Change Orders;

c. Owner has been required to correct defective Work or complete Work in accordance with Paragraph 13.09; or

d. Engineer has actual knowledge of the occurrence of any of the events enumerated in Paragraph 15.02.A.

C. *Payment Becomes Due:*

1. Ten days after presentation of the Application for Payment to Owner with Engineer's recommendation, the amount recommended will (subject to the provisions of Paragraph 14.02.D) become due, and when due will be paid by Owner to Contractor.

D. *Reduction in Payment:*

1. Owner may refuse to make payment of the full amount recommended by Engineer because:

a. claims have been made against Owner on account of Contractor's performance or furnishing of the Work;

b. Liens have been filed in connection with the Work, except where Contractor has delivered a specific bond satisfactory to Owner to secure the satisfaction and discharge of such Liens;

c. there are other items entitling Owner to a set-off against the amount recommended; or

d. Owner has actual knowledge of the occurrence of any of the events enumerated in Paragraphs 14.02.B.5.a through 14.02.B.5.c or Paragraph 15.02.A.

2. If Owner refuses to make payment of the full amount recommended by Engineer, Owner will give Contractor immediate written notice (with a copy to Engineer) stating the reasons for such action and promptly pay Contractor any amount remaining after deduction of the amount so withheld. Owner shall promptly pay Contractor the amount so withheld, or any adjustment thereto agreed to by Owner and Contractor, when Contractor remedies the reasons for such action.

3. Upon a subsequent determination that Owner's refusal of payment was not justified, the amount wrongfully withheld shall be treated as an amount due as determined by Paragraph 14.02.C.1 and subject to interest as provided in the Agreement.

14.03 *Contractor's Warranty of Title*

A. Contractor warrants and guarantees that title to all Work, materials, and equipment covered by any Application for Payment, whether incorporated in the Project or not, will pass to Owner no later than the time of payment free and clear of all Liens.

14.04 *Substantial Completion*

A. When Contractor considers the entire Work ready for its intended use Contractor shall notify Owner and Engineer in writing that the entire Work is substantially complete (except for items specifically listed by Contractor as incomplete) and request that Engineer issue a certificate of Substantial Completion.

B. Promptly after Contractor's notification, Owner, Contractor, and Engineer shall make an inspection of the Work to determine the status of completion. If Engineer does not consider the Work substantially complete, Engineer will notify Contractor in writing giving the reasons therefor.

C. If Engineer considers the Work substantially complete, Engineer will deliver to Owner a tentative certificate of Substantial Completion which shall fix the date of Substantial Completion. There shall be attached to the certificate a tentative list of items to be completed or corrected before final payment. Owner shall have seven days after receipt of the tentative certificate during which to

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make written objection to Engineer as to any provisions of the certificate or attached list. If, after considering such objections, Engineer concludes that the Work is not substantially complete, Engineer will, within 14 days after submission of the tentative certificate to Owner, notify Contractor in writing, stating the reasons therefor. If, after consideration of Owner's objections, Engineer considers the Work substantially complete, Engineer will, within said 14 days, execute and deliver to Owner and Contractor a definitive certificate of Substantial Completion (with a revised tentative list of items to be completed or corrected) reflecting such changes from the tentative certificate as Engineer believes justified after consideration of any objections from Owner.

D. At the time of delivery of the tentative certificate of Substantial Completion, Engineer will deliver to Owner and Contractor a written recommendation as to division of responsibilities pending final payment between Owner and Contractor with respect to security, operation, safety, and protection of the Work, maintenance, heat, utilities, insurance, and warranties and guarantees. Unless Owner and Contractor agree otherwise in writing and so inform Engineer in writing prior to Engineer's issuing the definitive certificate of Substantial Completion, Engineer's aforesaid recommendation will be binding on Owner and Contractor until final payment.

E. Owner shall have the right to exclude Contractor from the Site after the date of Substantial Completion subject to allowing Contractor reasonable access to remove its property and complete or correct items on the tentative list.

14.05 *Partial Utilization*

A. Prior to Substantial Completion of all the Work, Owner may use or occupy any substantially completed part of the Work which has specifically been identified in the Contract Documents, or which Owner, Engineer, and Contractor agree constitutes a separately functioning and usable part of the Work that can be used by Owner for its intended purpose without significant interference with Contractor's performance of the remainder of the Work, subject to the following conditions:

1. Owner at any time may request Contractor in writing to permit Owner to use or occupy any such part of the Work which Owner believes to be ready for its intended use and substantially complete. If and when Contractor agrees that such part of the Work is substantially complete, Contractor, Owner, and Engineer will follow the procedures of Paragraph 14.04.A through D for that part of the Work.

2. Contractor at any time may notify Owner and Engineer in writing that Contractor considers any such part of the Work ready for its intended use and substantially complete and request Engineer to issue a certificate of Substantial Completion for that part of the Work.

3. Within a reasonable time after either such request, Owner, Contractor, and Engineer shall make an inspection of that part of the Work to determine its status of completion. If Engineer does not consider that part of the Work to be substantially complete, Engineer will notify Owner and Contractor in writing giving the reasons therefor. If Engineer considers that part of the Work to be substantially complete, the provisions of Paragraph 14.04 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.

4. No use or occupancy or separate operation of part of the Work may occur prior to compliance with the requirements of Paragraph 5.10 regarding property insurance.

14.06 *Final Inspection*

A. Upon written notice from Contractor that the entire Work or an agreed portion thereof is complete, Engineer will promptly make a final inspection with Owner and Contractor and will notify Contractor in writing of all particulars in which this inspection reveals that the Work is incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.

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14.07 *Final Payment*

A. *Application for Payment:*

1. After Contractor has, in the opinion of Engineer, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, all maintenance and operating instructions, schedules, guarantees, bonds, certificates or other evidence of insurance, certificates of inspection, marked-up record documents (as provided in Paragraph 6.12), and other documents, Contractor may make application for final payment following the procedure for progress payments.

2. The final Application for Payment shall be accompanied (except as previously delivered) by:

   a. all documentation called for in the Contract Documents, including but not limited to the evidence of insurance required by Paragraph 5.04.B.6;

   b. consent of the surety, if any, to final payment;

   c. a list of all Claims against Owner that Contractor believes are unsettled; and

   d. complete and legally effective releases or waivers (satisfactory to Owner) of all Lien rights arising out of or Liens filed in connection with the Work.

3. In lieu of the releases or waivers of Liens specified in Paragraph 14.07.A.2 and as approved by Owner, Contractor may furnish receipts or releases in full and an affidavit of Contractor that: (i) the releases and receipts include all labor, services, material, and equipment for which a Lien could be filed; and (ii) all payrolls, material and equipment bills, and other indebtedness connected with the Work for which Owner might in any way be responsible, or which might in any way result in liens or other burdens on Owner's property, have been paid or otherwise satisfied. If any Subcontractor or Supplier fails to furnish such a release or receipt in full, Contractor may furnish a bond or other collateral satisfactory to Owner to indemnify Owner against any Lien.

B. *Engineer's Review of Application and Acceptance:*

1. If, on the basis of Engineer's observation of the Work during construction and final inspection, and Engineer's review of the final Application for Payment and accompanying documentation as required by the Contract Documents, Engineer is satisfied that the Work has been completed and Contractor's other obligations under the Contract Documents have been fulfilled, Engineer will, within ten days after receipt of the final Application for Payment, indicate in writing Engineer's recommendation of payment and present the Application for Payment to Owner for payment. At the same time Engineer will also give written notice to Owner and Contractor that the Work is acceptable subject to the provisions of Paragraph 14.09. Otherwise, Engineer will return the Application for Payment to Contractor, indicating in writing the reasons for refusing to recommend final payment, in which case Contractor shall make the necessary corrections and resubmit the Application for Payment.

C. *Payment Becomes Due:*

1. Thirty days after the presentation to Owner of the Application for Payment and accompanying documentation, the amount recommended by Engineer, less any sum Owner is entitled to set off against Engineer's recommendation, including but not limited to liquidated damages, will become due and will be paid by Owner to Contractor.

14.08 *Final Completion Delayed*

A. If, through no fault of Contractor, final completion of the Work is significantly delayed, and if Engineer so confirms, Owner shall, upon receipt of Contractor's final Application for Payment (for Work fully completed and accepted) and recommendation of Engineer, and without terminating the Contract, make payment of the balance due for that portion of the Work fully completed and accepted. If the remaining balance to be held by Owner for Work not fully completed or corrected is less than the retainage stipulated in the Agreement, and if bonds have been furnished as required in Paragraph 5.01, the written consent of the surety to the payment of the balance due for that portion of the Work fully completed and

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accepted shall be submitted by Contractor to Engineer with the Application for such payment. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of Claims.

14.09 *Waiver of Claims*

A. The making and acceptance of final payment will constitute:

1. a waiver of all Claims by Owner against Contractor, except Claims arising from unsettled Liens, from defective Work appearing after final inspection pursuant to Paragraph 14.06, from failure to comply with the Contract Documents or the terms of any special guarantees specified therein, or from Contractor's continuing obligations under the Contract Documents; and

2. a waiver of all Claims by Contractor against Owner other than those previously made in accordance with the requirements herein and expressly acknowledged by Owner in writing as still unsettled.

ARTICLE 15 – SUSPENSION OF WORK AND TERMINATION

15.01 *Owner May Suspend Work*

A. At any time and without cause, Owner may suspend the Work or any portion thereof for a period of not more than 90 consecutive days by notice in writing to Contractor and Engineer which will fix the date on which Work will be resumed. Contractor shall resume the Work on the date so fixed. Contractor shall be granted an adjustment in the Contract Price or an extension of the Contract Times, or both, directly attributable to any such suspension if Contractor makes a Claim therefor as provided in Paragraph 10.05.

15.02 *Owner May Terminate for Cause*

A. The occurrence of any one or more of the following events will justify termination for cause:

1. Contractor's persistent failure to perform the Work in accordance with the Contract Documents (including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment or failure to adhere to the Progress Schedule established under Paragraph 2.07 as adjusted from time to time pursuant to Paragraph 6.04);

2. Contractor's disregard of Laws or Regulations of any public body having jurisdiction;

3. Contractor's repeated disregard of the authority of Engineer; or

4. Contractor's violation in any substantial way of any provisions of the Contract Documents.

B. If one or more of the events identified in Paragraph 15.02.A occur, Owner may, after giving Contractor (and surety) seven days written notice of its intent to terminate the services of Contractor:

1. exclude Contractor from the Site, and take possession of the Work and of all Contractor's tools, appliances, construction equipment, and machinery at the Site, and use the same to the full extent they could be used by Contractor (without liability to Contractor for trespass or conversion);

2. incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere; and

3. complete the Work as Owner may deem expedient.

C. If Owner proceeds as provided in Paragraph 15.02.B, Contractor shall not be entitled to receive any further payment until the Work is completed. If the unpaid balance of the Contract Price exceeds all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by Owner arising out of or relating to completing the Work, such excess will be paid to Contractor. If such claims, costs, losses, and damages exceed such unpaid balance, Contractor shall pay the difference to Owner. Such claims, costs, losses, and damages incurred by Owner will be reviewed by Engineer as to their reasonableness and, when so approved by Engineer, incorporated in a Change Order. When exercising any rights or remedies under this Paragraph, Owner shall not be required to obtain the lowest price for the Work performed.

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D. Notwithstanding Paragraphs 15.02.B and 15.02.C, Contractor's services will not be terminated if Contractor begins within seven days of receipt of notice of intent to terminate to correct its failure to perform and proceeds diligently to cure such failure within no more than 30 days of receipt of said notice.

E. Where Contractor's services have been so terminated by Owner, the termination will not affect any rights or remedies of Owner against Contractor then existing or which may thereafter accrue. Any retention or payment of moneys due Contractor by Owner will not release Contractor from liability.

F. If and to the extent that Contractor has provided a performance bond under the provisions of Paragraph 5.01.A, the termination procedures of that bond shall supersede the provisions of Paragraphs 15.02.B and 15.02.C.

15.03 *Owner May Terminate For Convenience*

A. Upon seven days written notice to Contractor and Engineer, Owner may, without cause and without prejudice to any other right or remedy of Owner, terminate the Contract. In such case, Contractor shall be paid for (without duplication of any items):

1. completed and acceptable Work executed in accordance with the Contract Documents prior to the effective date of termination, including fair and reasonable sums for overhead and profit on such Work;

2. expenses sustained prior to the effective date of termination in performing services and furnishing labor, materials, or equipment as required by the Contract Documents in connection with uncompleted Work, plus fair and reasonable sums for overhead and profit on such expenses;

3. all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) incurred in settlement of terminated contracts with Subcontractors, Suppliers, and others; and

4. reasonable expenses directly attributable to termination.

B. Contractor shall not be paid on account of loss of anticipated profits or revenue or other economic loss arising out of or resulting from such termination.

15.04 *Contractor May Stop Work or Terminate*

A. If, through no act or fault of Contractor, (i) the Work is suspended for more than 90 consecutive days by Owner or under an order of court or other public authority, or (ii) Engineer fails to act on any Application for Payment within 30 days after it is submitted, or (iii) Owner fails for 30 days to pay Contractor any sum finally determined to be due, then Contractor may, upon seven days written notice to Owner and Engineer, and provided Owner or Engineer do not remedy such suspension or failure within that time, terminate the Contract and recover from Owner payment on the same terms as provided in Paragraph 15.03.

B. In lieu of terminating the Contract and without prejudice to any other right or remedy, if Engineer has failed to act on an Application for Payment within 30 days after it is submitted, or Owner has failed for 30 days to pay Contractor any sum finally determined to be due, Contractor may, seven days after written notice to Owner and Engineer, stop the Work until payment is made of all such amounts due Contractor, including interest thereon. The provisions of this Paragraph 15.04 are not intended to preclude Contractor from making a Claim under Paragraph 10.05 for an adjustment in Contract Price or Contract Times or otherwise for expenses or damage directly attributable to Contractor's stopping the Work as permitted by this Paragraph.

ARTICLE 16 – DISPUTE RESOLUTION

16.01 *Methods and Procedures*

A. Either Owner or Contractor may request mediation of any Claim submitted to Engineer for a decision under Paragraph 10.05 before such decision becomes final and binding. The mediation will be governed by the Construction Industry Mediation Rules of the American Arbitration Association in effect as of the Effective Date of the Agreement. The request for mediation shall be submitted in writing to the American Arbitration Association and the other party to the Contract. Timely submission of the request shall stay the effect of Paragraph 10.05.E.

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B. Owner and Contractor shall participate in the mediation process in good faith. The process shall be concluded within 60 days of filing of the request. The date of termination of the mediation shall be determined by application of the mediation rules referenced above.

C. If the Claim is not resolved by mediation, Engineer's action under Paragraph 10.05.C or a denial pursuant to Paragraphs 10.05.C.3 or 10.05.D shall become final and binding 30 days after termination of the mediation unless, within that time period, Owner or Contractor:

1. elects in writing to invoke any dispute resolution process provided for in the Supplementary Conditions; or

2. agrees with the other party to submit the Claim to another dispute resolution process; or

3. gives written notice to the other party of the intent to submit the Claim to a court of competent jurisdiction.

ARTICLE 17 – MISCELLANEOUS

17.01 *Giving Notice*

A. Whenever any provision of the Contract Documents requires the giving of written notice, it will be deemed to have been validly given if:

1. delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended; or

2. delivered at or sent by registered or certified mail, postage prepaid, to the last business address known to the giver of the notice.

17.02 *Computation of Times*

A. When any period of time is referred to in the Contract Documents by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

17.03 *Cumulative Remedies*

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract Documents. The provisions of this Paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right, and remedy to which they apply.

17.04 *Survival of Obligations*

A. All representations, indemnifications, warranties, and guarantees made in, required by, or given in accordance with the Contract Documents, as well as all continuing obligations indicated in the Contract Documents, will survive final payment, completion, and acceptance of the Work or termination or completion of the Contract or termination of the services of Contractor.

17.05 *Controlling Law*

A. This Contract is to be governed by the law of the state in which the Project is located.

17.06 *Headings*

A. Article and paragraph headings are inserted for convenience only and do not constitute parts of these General Conditions.

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SECTION 00801
SUPPLEMENTAL CONDITIONS (For THP Pre-Selection Only)

PART 1 GENERAL

A. A copy of the General Conditions that are anticipated to be used in the agreement between the Owner and the Contractor (Hereafter called the Anticipated Prime Agreement) is attached. To the extent that the provisions of the Anticipated Prime Agreement apply to the work of the Supplier, the Contractor shall assume toward the Supplier all obligation and responsibilities that the Owner assumes toward the Contractor under the attached General Conditions. Likewise, the Supplier shall assume toward the Contractor all obligations and responsibilities which the Contractor assumes toward the Owner and Engineer under the attached General Conditions. The Contractor shall have the benefit of all rights, remedies and redress against the Supplier that the Owner has against the Contractor under the attached General Conditions. Likewise, the Supplier shall have the benefit of all rights, remedies and redress against the Contractor that the Contractor has against the Owner under the attached General Conditions.

B. Supplier as used in this document shall mean the THP equipment supplier who is under subcontract to the Contractor. Contractor as used in this document shall mean the General Contractor who will hold the subcontract with the Supplier.

C. The following additional terms and conditions supplement and further define the terms and conditions in the attached General Conditions.

1. Taxes – Supplier's price shall include all import duties, tariffs, and taxes imposed by any U.S. or foreign taxing agency under current law, including value added taxes. Supplier's price shall be adjusted to account for any new taxes not currently imposed (excluding income taxes), and for any increases or decreases in value added taxes.

2. Senior Supplier Personnel Commitment – Supplier will make its most experienced senior personnel available on a priority basis as reasonably required to support the performance of Supplier subcontract.

3. Maintaining Available Personnel Resources – Supplier will take all steps reasonably required to assure that the firm's commitments to other customers do not impair its ability to perform the Supplier's Subcontract.

4. Interface with Other System Suppliers and the Contractor – Supplier will assist the Contractor with regard to interface and interoperability of Suppliers system with suppliers for other systems, including the fats oils and grease system, dewatering systems, digester system, combined heat and power system, and various pumping systems.

5. Schedule – Supplier agrees to provide delivery of equipment, material or services within the number of days established below for each milestone:
   a. Executing an agreement with the Contractor for this work – Within 21 calendar days of the date when the Contractor executes the agreement with the Owner.
   b. Provision of proof of the required bonds and insurance – At the same time the agreement with the Contractor is executed.
   c. Delivery of submittals to Contractor – Within 30 calendar days after executing the agreement with the Contractor.

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d. Delivery of equipment and materials – Within 140 calendar days of receiving the release for equipment manufacturing from Contractor.
e. Completion of functional testing – Within 14 calendar days of receiving notification from the Contractor that the equipment is ready for functional testing.
f. Operation of the THP System during from the commencement of Commissioning through Final Acceptance of the entire biosolids facility.

6. Liquidated Damages - The Supplier will be subject to payment of liquidated damages to the Contractor for each day of delay in meeting the Supplier's schedule milestones (See above). The amount of liquidated damages paid by the Supplier shall equal to the number of days of delay caused by the Supplier multiplied by $2,000 per day for each incident. Liquidated damages shall be limited to ten percent of the Suppliers contract amount.

7. The Supplier's personnel and anyone else under contract to the Supplier must comply with the Contractor's health and safety plan and other requirements while on the construction site.

8. Equipment and material purchase/shipping terms shall be FOB Franklin WRF site.

9. Insurance - Before beginning work under the Subcontract, the Supplier shall obtain the insurance required under the Subcontract and shall provide the Contractor with properly completed insurance certificate forms. The Contractor shall be given thirty calendar days written notice in the event of cancellation or modification of any of the coverage. Contractor may withhold such payments as it may deem necessary to guarantee compliance with these insurance requirements. Supplier shall take out and maintain during the life of the Subcontract and for two years following substantial completion of the Project, with insurers satisfactory to Contractor, insurance coverage with minimum limits as follows:

a. Commercial General Liability (occurrence form) ("CGL"):

1)	Each Occurrence:	$1,000,000
2)	Fire Damage:	$50,000
3)	Medical Expenses (any one person)	$10,000
4)	Personal & Advertising Injury:	$1,000,000
5)	General Aggregate:	$2,000,000 (To apply to this project only)
6)	Completed Operations Aggregate:	$2,000,000

Note – The CGL policy shall include full Contractual Liability coverage and shall not exclude explosion, collapse, and underground hazards.

b.	Automobile Liability:	$1,000,000 (combined single limit)
c.	Workers' Compensation:	Statutory Limits
d.	Employer's Liability:	$500,000/$500,000/$500,000
e.	Excess or Umbrella liability (occurrence form)	Limits required by the Owner for the Project or $1,000,000, whichever is greater.

Note - Umbrella limits shall apply as excess insurance to underlying CGL, Automobile Liability, and Employer's Liability limits as specified above.

10. Confidentiality – Any publication by the Supplier of detailed operating or design data about the THP system must be approved by the Owner.

11. Assignment – The Supplier's Subcontract is not assignable by the Supplier.

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END OF SECTION

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SECTION 01025A
MEASUREMENT AND PAYMENT (FOR THP PRE-SELECTION ONLY)

PART 1 GENERAL

1.01 GENERAL

A. This Section defines the Work to be included in each Bid Item of the Proposal Bid Form of these Contract Documents. Payment will be made based on the specified items included in the description for each Bid Item.

B. All Work under this Contract shall be complete, in-place, fully tested, ready for continuous uninterrupted service and Final Acceptance by the OWNER. Required items of Work and incidentals necessary for the satisfactory completion of the Work which are not specifically listed in the Bid Form, and which are not specified in this Section to be measured or included in one of the items listed in the Bid Form, shall be considered as incidental to the Work.

C. All costs including all such items as freight, taxes, and overhead and profit, shall be included in the lump sum or unit prices bid for the various Bid Items unless specifically noted otherwise. All Contract prices included within the Bid Form will be full compensation for all labor, materials, tools, equipment, overhead and incidentals necessary to complete the Work as shown on the Contract Drawings and/or as specified in the Contract Documents unless specifically noted otherwise.

D. Measurement of an item of Work shall be by the unit indicated within the Bid Form.

E. Final payment quantities of each Unit Price Bid Item shall be determined upon completion of the Work in the manner established for each Bid Item in this Section of the Contract Documents.

F. Payment for all Bid Items listed in the Bid Form shall constitute full compensation for all Work shown and/or specified to be performed under each Bid Item and shall include all necessary and incidental Work not specified to be included in any other Bid Item listed in the Bid Form.

G. A retainage of ten percent will be held on pay requests made by the Contractor to the Owner. In turn, the Contractor will hold ten percent retainage on pay requests from the THP System Supplier.

H. There will be no deposits provided to the THP System Supplier.

PART 2 BASE BID

2.01 BID ITEMS 1 THROUGH 14 - SCOPE

A. Bid Item 1 – Pre-Dewatered Storage Bin

1. The Pre-Dewatered Storage Bins are the most upstream limit of the THP System Supplier's scope of supply. Dewatered sludge is conveyed from the centrifuges' solids chute to the

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top inlet of the pre-dewatered storage bins by others. This bid item includes the steel bins with live bottom hoppers, and all pipe and duct connections to the bins. The downstream limit of the bin is the bottom connections to the THP feed pumps.

2. Refer to specification 11243 for more information on what is included in this bid item.

B. Bid Item 2 – Progressive Cavity Pumps

1. This bid item includes all of the progressing cavity pumps associated in the Suppliers scope. The scope of each progressing cavity pump will begin at the suction flange of the pump and end at the discharge flange of the pump, with the exception of the instruments listed in the below pump specification (pressure gauges, etc.). The pump, motor, and base plate are all within the scope.

2. Refer to the following specifications for more information on what is included in this bid item:
    1. 11315 – Progressing Cavity Pumps (For THP Pre-Selection Only)
    2. 16150 – Motors

C. Bid Item 3 – Water Service Pumps

1. All of the water service pumps associated with the THP system are included in this bid item. The scope of each water service pump will begin at the suction flange of the pump and end at the discharge flange of the pump, with the exception of the instruments listed in specification section 11050 (pressure gauges, etc.). The pump, motor, and base plate are within the scope.

2. Refer to the following specifications for more information on what is included in this bid item:
    1. 11050 – General Requirements for Centrifugal and Axial Flow Pumping Equipment

D. 16150 – Motors Bid Item 4 – Pressure Vessel(s)

1. Dewatered sludge is conveyed from the pre-dewatered storage bin to the pressure vessel(s) by progressing cavity pumps, all of which are in the THP System Supplier's scope of supply. After the sludge has been heated and pressurized in the vessel, it exits the vessel to flow further downstream in the process. This pressure vessel bid item includes the tank itself, all pipe and duct connections, and structural support of the vessel.

2. Refer to specification 11351 for more information on what is included in this bid item.

E. Bid Item 5 – Valves and Actuators

1. This bid item includes all of the valves and actuators in the Suppliers scope. Each valve and actuator will begin at the upstream flange of the valve and end at the downstream flange of the valve. The valve and entire actuator (includes motor if motor actuated) are all included in this bid item. For pneumatic actuators, the connection of the pneumatic piping

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to the actuator is included in this bid item. The piping and headers fall within the air compressor system bid item.

2. Refer to specification 15100 for more information on what is included in this bid item.

F. Bid Item 6 – Piping Systems

1. This bid item includes the pipes and fittings and all other piping specialties, as well as supports, hangers and restraints. This bid item does not include the heat tracing, insulation and cladding, valves, or inline instruments (flow meters, etc.). However, the piping systems scope does include any and all supports necessary for valves and other online instruments. The piping system encompasses all pipes up to their flanged connections to equipment provided by the supplier.

2. Refer to the following specifications for more information on what is included in this bid item:
    1) 15051 – Piping General Requirements
    2) 15061 – Steel Pipe and Fittings
    3) 15064 – Plastic Pipe and Fittings
    4) 15067 – Stainless Steel Pipe and Fittings
    5) 15072 – Ductile Iron Pipe and Fittings
    6) 15120 – Piping Specialties
    7) 15140 – Pipe Hangers, Supports & Restraints

G. Bid Item 7 – Heat Tracing, Insulation and Cladding

1. This bid item includes all heat tracing, insulation and cladding required for any piping system, pressure vessel, or any other equipment within the THP System Supplier's scope of supply that requires temperature control.

2. Refer to the following specifications for more information on what is included in this bid item:
    1. 15250 – Thermal Insulation for Process Equipment & Piping
    2. 15257 – Electrical Heat Tracing

H. Bid Item 8 – Air Compressor System

1. Refer to specification 11373 for information on what is included in this bid item.

I. Bid Item 9 – Heat Exchangers

1. This bid item includes all heat exchangers included in the Supplier's scope. This bid item includes each heat exchanger from the inlet connections for the hot sludge and the cooling water supply, and ends at the outlet connections for the cooling water return and the cooled sludge. The exception to this is the temperature and pressure elements required for each heat exchanger. This bid item does NOT include the pumps and control valves and piping that convey cooling water and sludge to and from the heat exchangers.

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2. Refer to specification 15754 for more information on what is included in this bid item.

J. Bid Item 10 – Chopper Pumps

1. This bid item includes all chopper pumps included in the Supplier's scope. This bid item includes each chopper pump beginning at the suction flange of the pump and ending at the discharge flange of the pump, with the exception of the instruments listed in specification section 11318 (pressure gauges, etc.). The pump, motor, and base plate are all included in this bid item.

2. Refer to specification 11318 for more information on what is included in this bid item.

K. Bid Item 11 – Variable Frequency Drives (VFDs)

1. This bid item includes all variable frequency drives (VFDs) included in the Supplier's scope.

2. Refer to specification 16370 for more information on what is included in this bid item.

L. Bid Item 12 – Instrumentation and Controls

1. This bid item includes all instruments and controls required to operate the entire system within the Suppliers scope. This includes a PLC.

2. Refer to the following specifications for more information on what is included in this bid item:
    1. 13300 – I&C General Provisions
    2. 13311 – PLC Hardware and Software
    3. 13320 – Control and Data Network Equipment
    4. 13321 – Fiber Optic Cabling and Equipment
    5. 13330 – Control Panel Enclosures and Panel Equipment
    6. 13340 – I&C Instruments

M. Bid Item 13 – Electrical

1. Refer to the following specifications for more information on what is included in this bid item:
    1. 16000 – Electrical General Provisions
    2. 16110 – Raceways, Boxes, Fittings and Supports
    3. 16120 – Wires and Cables
    4. 16150 – Motors
    5. 16191A – Miscellaneous Equipment (For THP Pre-Selection Only)
    6. 16370 – Variable Frequency Drives
    7. 16500 – Lighting Systems

N. Bid Item 14 – Other Equipment, Material and Services Not Included in Items 1 Through 13

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1. This bid item includes all other equipment, materials and services not included in bid items 1 through 13, but required to provide a fully functioning THP system.

2.02 BID ITEMS 1 THROUGH 14 – MEASUREMENT

These bid items will be measured by completion of milestones. The milestones, as well as what needs to be done to complete the milestone, are described below.

A. Receipt of Approved Submittals

1. The individual specification sections list the submittals required for each of the bid items.

2. This milestone shall be considered complete for a bid item when the General Contractor receives one of the following approval codes from the Engineer for all of the submittals required in specifications associated with this bid item.
   1. Code 1 – APPROVED
   2. Code 2 – APPROVED AS NOTED

3. Please note that a "Code 3 – APPROVED AS NOTED – CONFIRM" or a "Code 4 – APPROVED AS NOTED – RESUBMIT" do NOT qualify as a final approved submittal, as they require additional action, to either confirm the Engineer's comments or resubmit the submittal per the Engineer's comments.

B. Delivery of Equipment to Job Site

1. This milestone shall be considered complete for a bid item when the General Contractor signs off on the delivered equipment.

2. If equipment is shipped in pieces separately, the milestone shall be completed when the General Contractor accepts the last piece of equipment delivered for that bid item.

C. Completion of Functional Testing

1. For the functional testing to be completed for a bid item, the THP System Supplier representative for the equipment under that bid item must have signed off on the installation, assisted in the functional testing of the equipment, and signed off on the successful completion of functional testing.

2. This milestone shall be considered complete for a bid item when the Owner/Engineer approve the Functional Testing Report that the General Contractor submits to the City of Franklin.

D. Completion of Commissioning

1. For the commissioning to be completed, the THP System Supplier's representative must have assisted in the introduction of biosolids through the THP system.

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2. This milestone shall be considered complete when the Owner/Engineer approve the Commissioning Report that the General Contractor submits to the City of Franklin.

E. Operation and Maintenance training

1. This milestone, split into three milestones, shall be considered complete for a bid item as described below.
   1. Approved operation and maintenance manuals as defined in Section 01730.
   2. Successful completion of operation and maintenance training as defined in Section 01664.
   3. Approved training session video as defined in 01664.

F. Completion of Acceptance Testing

1. This milestone is a measure of the services of the THP System Supplier's representatives. For the acceptance testing to be completed, the THP System Supplier's representatives must have assisted in the tuning of the THP system in order for it to operate at conditions that meet the performance guarantees.

2. This milestone shall be considered complete when the Owner/Engineer approve the Acceptance Testing Report that the General Contractor submits to the City of Franklin.

2.03 BID ITEMS 1 THROUGH 14 – PAYMENT

Partial payment on bid item 1 through 14 will be made as the milestones listed in Paragraph 2.02 above are completed for each bid item. Payment for each milestone for each bid item will be as shown below. Where the phrase "bid amount" is used it refers to the bid amount on the Attachment D of the THP Pre-Selection Package RFP.

A. Receipt of Approved Submittals: When this milestone is reached for a bid item, the Supplier may apply for payment of five (5) percent of the bid amount for that bid item.

B. Delivery of Equipment to Job Site: When this milestone is reached for a bid item, the Supplier may apply for payment of fourth five (50) percent of the bid amount for that bid item.

C. Completion of Functional Testing: When this milestone is reached for a bid item, the Supplier may apply for payment of twenty five (25) percent of the bid amount for that bid item.

D. Completion of Commissioning: When this milestone is reached for a bid item, the Supplier may apply for payment of five (5) percent of the bid amount for that bid item.

E. Completion of Acceptance Testing: When this milestone is reached for a bid item, the Supplier may apply for payment of five (5) percent of the bid amount for that bid item.

F. Operation and Maintenance Training: Payment for this milestone will be split into three parts.

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1. Payment for *approved operation and maintenance manuals*: When this milestone is reached for a bid item, the Supplier may apply for payment of five (5) percent of the bid amount for that bid item.

2. Payment for *completed operation and maintenance training*: When this milestone is reached for a bid item, the Supplier may apply for payment of three (3) percent of the bid amount for that bid item.

3. Payment for *approved training session videos:* When this milestone is reached for a bid item, the Supplier may apply for payment of two (2) percent of the bid amount for that bid item.

2.04 BID ITEM 15 – PERFORMANCE WARRANTY BOND

A. Scope:

1. The warranty includes all equipment included in the THP System Supplier's scope of supply as described in this specification section and in Section 11351.

2. The THP System Supplier shall provide to the Owner a warranty bond equal to the THP equipment contract amount as a guarantee that the installed system will meet all performance requirements listed in Appendix XX[TJN1]. The bond shall be for a term of 18 months from the date of written acceptance/approval of the THP system by the Engineer and the Owner.

B. Measurement:

1. Request for payment on this item may be made upon acceptance of the warranty bond by the Engineer.

C. Payment:

1. Payment will equal the value listed for Warranty Bond Bid Item (Bid Item 15) listed on the approved bid form (Attachment D of the THP Pre-Selection Package RFP).

2.05 BID ITEM 16 – COST TO ACHIEVE CERTIFICATION AS EQUIVALENT CLASS A TECHNOLOGY

A. Scope:

1. The THP System Supplier shall be responsible to achieve certification as an equivalent Class A technology from the EPA. This includes the costs of any and all pathogen testing required to satisfy the EPA of the system's equivalency.

B. Measurement:

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1. This milestone will be considered complete when the City of Franklin receives a letter from the EPA stating that the Franklin system has achieved Class A equivalent certification.

C. Payment:

1. Payment will equal the value listed for the Cost to Achieve Certification as Equivalent Class A Technology Bid Item (Bid Item 16) listed on the approved bid form (Attachment D of the THP Pre-Selection Package RFP).

2.06 BID ITEM 17 – OPTIMIZATION AND OPERATOR SHADOWING

A. Scope:
1. This bid item includes optimization and operation of the entire system included in the Supplier's scope and operator shadowing.
1) The optimization period shall begin the day after the final performance guarantee has been met and approved by the Owner.
2) The optimization period shall end sixty days after the beginning of the optimization period.
3) During this period, Franklin WRF operation staff will shadow the THP System Supplier's Representative to gain experience with the system's operation.
a) Franklin WRF is manned 24 hours a day, 7 days a week (24/7); the THP System Supplier shall provide on-site personnel 24/7 during this 60 day period to allow plant staff on all 3 shifts ample time for shadowing. The System Supplier should budget to have multiple operation personnel at Franklin during these 60 days to be able to provide 24/7 on site operation.

B. Measurement:

1. Optimizing the system performance is defined as maintaining stable operation of the THP system that meets the performance guarantees, while fine tuning the operational set points to allow the system to run at its peak efficiency.
1. An example of this could be determining the most efficient time-temperature combination to produce the most volatile destruction within the digesters.

2. This milestone will be considered complete at the end of the optimization period as defined above.

C. Payment:

1. Payment will equal the value listed for the Optimization and Operator Shadowing Bid Item (Bid Item 17) listed on the approved bid form (Attachment D of the THP Pre-Selection Package RFP).

2.07 BID ITEM 18 - OPTIONAL ONE (1) YEAR SERVICE CONTRACT

A. Scope:

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1. The optional one year service contract is a continuation of the optimization and operator shadowing bid item and shall include complete operation, maintenance and optimization of the system; the exception to this is the System Supplier is only required to have personnel on site for one shift a day (8 hours) instead of all 3 shifts (24 hours). The scheduled maintenance and servicing of the system shall be at a minimum equal to the routine maintenance and service as outlined in the O&M manuals.

2. If the Owner decides to authorize this service contract, the contract shall commence the day after the end of the Optimization and Operator Shadowing period OR the day after sign authorization of this service contract, whichever comes last.

3. The service contract length shall be 365 calendar days.

B. Measurement:

1. This milestone will be considered complete after the THP System Supplier's Representative complete the 365th day of the service contract.

C. Payment:

1. Payment will occur monthly on a date determined during the negotiations of the service contract. Each monthly payment will equal one-twelfth (1/12th) the value listed for the Optional One Year Service Contract (Bid Item 17) listed on the approved bid form (Attachment D of the THP Pre-Selection Package).

2.08 BID ITEM 19 – PAYMENT AND PERFORMANCE BONDS

A. Scope

1. This bid item includes the purchase of a payment bond and a performance bond in accordance with the forms found in specification 00615 and 00610, respectively.

B. Measurement

1. This milestone will be considered complete after the Owner/Engineer receives proof of payment bond and performance bond insurance.

C. Payment

1. Payment will equal the value listed for the Payment and Performance Bond Bid Item (Bid Item 19) listed on the approved bid form (Attachment D of the THP Pre-Selection Package RFP), but shall not exceed 5% of the total project cost.

END OF SECTION

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SECTION 01100
SPECIAL PROJECT PROCEDURES

PART 1 GENERAL

1.01 SERVICES OF MANUFACTURERS' FIELD SERVICE TECHNICIAN

A. Bid prices for equipment furnished under Divisions 11, 13, 14, 15 and 16 shall include the cost of a competent field service technician of the manufacturers of all equipment to supervise the installation, adjustment and testing of the equipment and to instruct the Owner's operating personnel on operation and maintenance. The approved manufacturer's operation and maintenance data as specified in Section 01730 shall be delivered to the Engineer prior to instructing the Owner's personnel. This supervision may be divided into two or more time periods as required by the installation program or as directed by the Engineer.

B. After installation of the equipment has been completed and the equipment is presumably ready for operation, but 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 cracked or otherwise damaged parts)

2. Completeness in all details, as specified and required

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

C. Upon completion of this work, the manufacturer's field service technician shall submit, in triplicate, to the Engineer a complete, signed report of the results of his/her inspection, operation, adjustments and tests. The report shall include detailed descriptions of the points inspected, tests and adjustments made, quantitative results obtained if such are specified and suggestions for precautions to be taken to ensure proper maintenance.

D. A certificate from the manufacturer stating that the installation of the equipment is satisfactory, that the unit has been satisfactorily tested, is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the unit shall be submitted prior to the startup and performance demonstration hereinafter specified. The certificate shall indicate date and time instruction was given and names of operating personnel in attendance. This certification shall be submitted on the certification sheet, a sample of which is at the end of this Section.

E. See the detailed Specifications for additional requirements for furnishing the services of the manufacturer's field service technician.

F. For equipment furnished under other Divisions, unless otherwise specified, furnish the services of accredited field services technicians of the manufacturer only when some evident malfunction or over-heating makes such services necessary in the opinion of the Engineer.

1.02 OPERATING AND MAINTENANCE DATA

A. Operating and maintenance data covering all equipment furnished under Division 11, 13, 14, 15 and 16 shall be delivered directly to the Office of the Engineer, CDM Smith, Parkview Towers,

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210 25th Avenue North, Suite 1102, Nashville, Tennessee 37203. Data shall be prepared and submitted in full conformance with Section 01730. Final approved copies of operating and maintenance data shall have been delivered to the Engineer prior to scheduling the instruction period with the Owner.

1.03 INSTALLATION OF EQUIPMENT

A. Special care shall be taken to ensure proper alignment of all equipment with particular reference to mechanical equipment such as pumps, blowers and electric drives. The units shall be carefully aligned on their foundations by qualified millwrights after their sole plates have been shimmed to true alignment at the anchor bolts. The anchor bolts shall be set in place and the nuts tightened against the shims. After the foundation alignments have been approved by the manufacturer, the bedplates or wing feet of the equipment shall be securely bolted in place. The alignment of equipment shall be further checked after securing to the foundations and after confirmation of all alignments the sole plates shall be finally grouted in place. The Contractor shall be responsible for the exact alignment of equipment with associated piping, and under no circumstances, will "pipe springing" be allowed.

B. All wedges, shims, filling pieces, keys, packing, red on white lead grout, or other materials necessary to properly align, level and secure apparatus in place shall be furnished by the Contractor. All parts intended to be plumb or level must be proven exactly so. Any grinding necessary to bring parts to proper bearing after erection shall be done at the expense of the Contractor.

1.04 SLEEVES AND OPENINGS

A. Provide all openings, channels, chases, etc. and install anchor bolts and other items to be embedded in concrete, as required to complete the work under this Contract, together with those required by subcontractors and shall do all cutting and patching, excepting cutting and patching of materials of a specified trade and as stated otherwise in the following Paragraph.

B. Coordinate with the subcontractors to provide all sleeves, inserts, hangers, anchor bolts, etc. of the proper size and material for the execution of the work. Be responsible for any corrective cutting and refinishing required to make the necessary openings, chases, etc. In no case shall beams, lintels or other structural members be cut without the written approval of the Engineer.

1.05 RELOCATIONS

A. Be responsible for the relocation of structures, including but not limited to light poles, signs, sign poles, fences, piping, conduits and drains that interfere with the positioning of the work as set out on the Drawings. The cost of all such relocations shall be included in the bid for the project and shall not result in any additional cost to the Owner.

1.06 OBSTRUCTIONS

A. The attention of the Contractor is drawn to the fact that during excavation at the Project site, the possibility exists of the Contractor encountering various water, chemical, electrical, or other lines not shown on the Drawings. Exercise extreme care before and during excavation to locate and flag these lines so as to avoid damage to the existing lines. Should damage occur to an existing line, repair the line at no cost to the Owner.

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B. It is the responsibility of the Contractor to ensure that all utility or other poles, the stability of which may be endangered by the close proximity of excavation, are temporarily stayed in position while work proceeds in the vicinity of the pole and that the utility or other companies concerned be given reasonable advance notice of any such excavation by the Contractor.

1.07 PROVISIONS FOR CONTROL OF EROSION

A. Sufficient precautions in accordance with Section 02270 shall be taken during construction to minimize the run-off of polluting substances such as silt, clay, fuels, oils, bitumen, calcium chloride, or other polluting materials harmful to humans, fish, or other life, into the supplies and surface waters of the State. Control measures must be adequate to assure that turbidity in the receiving water will not be increased more than 10 nephelometric turbidity units (NTU), or as otherwise required by the State or other controlling body, in water used for public water supply or fish unless limits have been established for the particular water. In surface water used for other purposes, the turbidity must not exceed 25 NTU unless otherwise permitted. Special precautions shall be taken in the use of construction equipment to prevent operations which promote erosion.

B. Erosion and sedimentation control shall conform to the requirements of the Tennessee Erosion & Sedimentation Control Handbook.

1.08 PROVISIONS FOR THE CONTROL OF DUST

A. Sufficient precautions shall be taken during construction to minimize the amount of dust created. Wetting down the site may be required or as directed by the Engineer to prevent dust as a result of vehicular traffic.

B. Refer to Section 01562 for additional requirements.

1.09 ARCHITECTURAL COATINGS

A. Maintain coordination among all Sections (windows, window walls, louvers, doors and frames, etc) requiring PVC and PVF coatings. All coatings shall match to the satisfaction of the Engineer with regard to color and texture. Items rejected by the Engineer shall promptly be removed from the job site.

1.10 ON SITE STORAGE

A. Attention is invited to special storage requirements and possible charges for noncompliance of on site storage requirements for materials and equipment as specified in Section 01600.

1.11 VALVE INDICES

A. Furnish and install tags for all valves, sluice gates and weir gates required on the work. Tags on above ground valves shall be non-corrosive metal or plastic, 2-in in diameter, 19 gauge thick. Buried valve tags shall be secured to a concrete base as shown on the Drawings. Submit to the Engineer for review, two samples of each type of tag proposed and the manufacturer's standard color chart and letter styles. Tags shall have stamped or engraved on them the information shown on the Drawings and the data described herein. Submit to the Engineer for approval no less than 120 days before start-up, a valve schedule containing all valves required for his/her work. The schedule shall contain a list of abbreviations used for each valve, the location, type, a

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number, words or abbreviations to identify the valve's function and the normal operating position. The information contained in the valve schedules shall be coded on the tags in a system provided by the Owner. Above ground valve tags shall be furnished with non-corrosive metal wire for attachment thereof. The tag shall not be attached to handwheel or crank operators or any part of the valve which would inhibit operation of the valve.

1.12 DISINFECTION

A. Clean, disinfect and bacteriologically test and clear, in accordance with applicable Tennessee Department of Health regulations, all water supply facilities affected by this project which shall come into contact with raw water, water being treated or treated water prior to placing the facility in operation. The above statement shall apply to both new facilities installed and existing facilities which are to be modified.

B. Employ a disinfection method, approved by the Engineer and Owner, that shall fully satisfy the Owner that adequate disinfection has been achieved prior to placing a facility on-line.

C. The cost of all disinfection work and bacteriological clearance tests shall be included in the prices quoted in the Bid Form.

D. Disinfection shall be performed in accordance with AWWA C651 and applicable Rules of the Tennessee Department of Health and the Tennessee Department of Environment and Conservation. Disinfection is required for both new facilities installed, and existing facilities which are modified.

E. Bacteriological tests shall be performed by the Owner in accordance with Section 01445.

F. Refer to Section 01445 for additional requirements.

1.13 CONNECTIONS TO EXISTING SYSTEMS

A. Perform all work necessary to locate, excavate and prepare for connections to the terminus of the existing systems all as shown on the Drawings or where directed by the Engineer. The cost for this work and for the actual connection of the existing mains shall be included in the bid for the project and shall not result in any additional cost to the Owner.

1.14 UTILITY CROSSINGS

A. It is intended that wherever existing utilities such as water, chemical, electrical or other service lines must be crossed, deflection of the pipe within recommended limits and cover shall be used to satisfactorily clear the obstruction unless otherwise indicated on the Drawings. However, when in the opinion of the Owner or Engineer this procedure is not feasible he/she may direct the use of fittings for a utility crossing as detailed on the Drawings.

1.15 EXISTING UTILITY PROTECTION

A. Existing utilities are shown in their approximate locations. Locate and protect all utilities whether shown on Drawings or not.

B. Contact utility companies at least 48 hours before starting construction so maintenance personnel can locate and protect facilities, if required by the utility company.

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1.16 WARRANTIES

A. All equipment supplied under this Section shall be warranted by the Contractor and the equipment manufacturers for a period of 1 year. Warranty period shall commence on the date of Owner acceptance.

B. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it shall be replaced in the machine(s) and the unit(s) restored to service at no expense to the Owner.

C. Obtain equipment warranties in accordance with Section 01740 from each of the respective suppliers or manufacturers for all the equipment specified under Divisions 11, 13, 14, 15 and 16. The form of warranty is included at the end of this Section.

D. The manufacturer's warranty period shall run concurrently with the Contractor's warranty or guarantee period. No exception to this provision shall be allowed. In the event that the manufacturer is unwilling to provide a one year warranty commencing at the time of Owner acceptance, obtain from the manufacturer a two year warranty starting at the time of equipment delivery to the job site. This 2 year warranty shall not relieve the Contractor of the 1 year warranty starting at the time of Owner acceptance of the equipment.

1.17 FINAL GUARANTEE

A. All work shall be guaranteed by the Contractor for a period of 1 year from and after the date of acceptance of the work by the Owner.

B. If, within the guarantee period, repairs or changes are required in connection with guaranteed work, which, in the opinion of the Engineer, is rendered necessary as the result of the use of materials, equipment or workmanship which are inferior, defective, or not in accordance with the terms of the Contract, promptly upon receipt of notice from the Owner and without expense to the Owner, do the following.

1. Place in satisfactory condition in every particular all of such guaranteed work and correct all defects therein.

2. Make good all damage to the building or site, or equipment or contents thereof, which, in the opinion of the Engineer, is the result of the use of materials, equipment or workmanship which are inferior, defective, or not in accordance with the terms of the contract.

3. Make good any work or material, or the equipment and contents of building, structure of site disturbed in fulfilling any such guarantee.

C. If the Contractor, after notice, fails within 10 days to proceed to comply with the terms of this guarantee, the Owner may have the defects corrected, and the Contractor and his/her surety shall be liable for all expense incurred, provided, however, that in case of an emergency where, in the opinion of the Owner, delay would cause loss or damage, repairs may be started without notice being given to the Contractor and the Contractor shall pay the cost thereof.

D. All special guarantees or warranties applicable to specific parts of the work as may be stipulated in the Contract Documents or other papers forming a part of this Contract shall be subject to the

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terms of this paragraph during the first year of life of each such guarantee. All special guarantees and manufacturers' warranties shall be assembled by the Contractor and delivered to the Engineer, along with a summary list thereof, before the acceptance of the Work.

1.18 ARCHEOLOGICAL FINDS

A. Notwithstanding anything to the contrary herein, in the event any archeological artifacts within the project are discovered during the course of the work, the Owner shall have and retain all right, title, and interest to such artifacts and shall have the further right, during the course of the Contract, to examine or cause to have examined, the site of the work for any such artifacts and to perform or have performed archeological excavations and all other related work to explore for, discover, recover and remove such artifacts from the site of the work. In the event the work or archeological examination and related work delays the Contractor's work, he/she shall be entitled to an extension of time to complete the work equal to the number of days he/she is thus delayed. Such delay shall be considered an excusable delay as defined in the supplementary conditions.

1.19 VOLTAGE RATINGS OF MOTORS

A. Unless otherwise specified, motors in excess of 1/3 Hp shall be nameplate rated for 460 Volt, 3 Phase, 60 Hz current. Motors of 1/3 Hp or less shall be suitable for operation on 115 Volt, single phase, 60 Hz current.

1.20 POWER FACTOR CORRECTION CAPACITORS

A. All single and multi speed three phase induction motors 5 Hp and larger shall be furnished with factory supplied power factor correction capacitors.

B. Capacitors shall be sized by the manufacturers such that over voltage due to self excitation will be prevented and transient torques limited to normal values. Full load power factor shall be corrected to not less than 0.95 where such correction will not violate the provisions of NEC Article 460.

C. Capacitor enclosures shall be compatible with those specified for their respective motors, i.e., dust-tight for indoor installation in non-hazardous areas and weatherproof for outdoor installations.

D. Capacitors shall be oil insulated with integral fuse protection and discharge resistor. The insulating medium shall be non-flammable and meet U.S. Environmental Protection Agency Standards.

E. Capacitors shall be installed under Division 16.

1.21 ELECTRICAL DEVICES

A. All motors, switches, controllers, panels, switchgear and other electrical devices shall be UL and/or CSA labeled and/or listed or shall be inspected and labeled in the field by an Owner approved certifying testing laboratory.

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1.22 MAINTENANCE OF EXISTING UTILITY SERVICE AND EXISTING WASTEWATER TREATMENT PLANT OPERATION

A. Cooperate at all times with the Owner in order to maintain plant operation with the least amount of interference and interruption possible. Public health and safety considerations shall exceed all others and the Contractor's schedule, plan and work shall, at all times, be subject to alteration and revision if necessary for public health and safety considerations.

B. Contractor is cautioned that this work is being performed on the site of an operating wastewater treatment plant. Take whatever precautions are necessary to maintain the flow of wastewater, electrical source, etc, to keep the plant in operation, where such operation is affected by the work. Should a partial or total shutdown be unavoidable, notify the Owner 72 hours in advance.

C. In no case will the Contractor be permitted to interfere with any existing service until all materials, supplies, equipment, tools and incidentals necessary to complete the work are on the job site.

D. The Engineer and the Owner reserve the right to require the Contractor to work 24 hours per day in all cases where interferences with existing utility service may result in health hazards, offensive conditions or serious inconveniences to persons served by the system.

E. Thirty days prior to any interference with existing water lines, submit to the Engineer his/her proposed method for maintaining service. The submittal shall include text and drawings in sufficient detail to describe the method, a list of equipment to be used, and a schedule for completing the work. No interference with service shall be made until the Engineer approves the method and schedule for completing the work.

F. Refer to Section 01014 for additional requirements.

1.23 EQUIPMENT DATA LIST

A. Obtain, prepare and submit a complete, detailed listing of equipment and motor data for all electrical items furnished under this Contract. This listing shall be submitted on Equipment Data Sheets, a sample of which is at the end of this Section.

B. Submit the Equipment Data List prior to the start-up and performance demonstration hereinafter specified.

1.24 PROTECTION AGAINST ELECTROLYSIS

A. Where dissimilar metals are used in conjunction with each other, suitable insulation shall be provided between adjoining surfaces so as to eliminate direct contact and any resulting electrolysis. The insulating material shall be bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other approved materials.

1.25 DAMAGE ON ACCOUNT OF HIGH WATER

A. Contractor will hold himself responsible for all damage done to his/her work by heavy rains or floods and he/she shall take all reasonable precautions to provide against damages by building such temporary dikes, channels, or shoring to carry off storm water as the nature of the work may require.

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1.26 TOOLS

A. Any special tools (including grease guns or other lubricating devices) which may be necessary for the adjustment, operation and maintenance of any equipment shall be furnished with the respective equipment.

B. Refer to Section 01600 for additional requirements.

1.27 GREASE, OIL, FUEL, ELECTRICAL POWER AND TESTING EQUIPMENT

A. All grease, oil and fuel required for testing of equipment shall be furnished with the respective equipment. Electric power and all equipment and tools required for testing of equipment shall be furnished by the contractor the cost of which shall be included in the prices quoted in the Bid Form. The Owner shall be furnished with a year's supply of required lubricants including grease and oil of the type recommended by the manufacturer with each item of equipment supplied under Divisions 11, 13, 14, 15 and 16.

B. Refer to Section 01600 for additional requirements.

1.28 EMERGENCY PHONE NUMBERS AND ACCIDENT REPORTS

A. Emergency phone numbers (fire, medical, police) shall be posted at the Contractor's phone and its location known to all.

B. Accidents shall be reported immediately to the Engineer by messenger or phone.

C. All accidents shall be documented and a fully detailed written report submitted to the Engineer after each accident.

1.29 STARTUP AND ACCEPTANCE OF THE TREATMENT PLANT AND RELATED SYSTEMS

A. General Requirements

1. Successfully execute the step-by-step procedure of startup and performance demonstration specified hereinafter.

2. The startup and performance demonstration shall be successfully executed prior to substantial completion and acceptance by the Owner of the Treatment Plant and its related systems.

3. All performance tests and inspections shall be scheduled at least 5 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 wastewater treatment facilities and all its related systems, all channels shall be flushed with non-potable water (clean creek water acceptable, no sewage). All plant effluent water, chemical conditioning systems, and sewage pipe lines,

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shall be filled and flushed with non-potable water and hydraulically checked for leaks, cracks, and defects. All sumps, tanks, basins, chambers and wet wells which under normal operating conditions will contain water, wastewater, chemicals, or sludge shall also be hydraulically checked using non-potable water for leaks, cracks, and defects. Items to be tested include but are not necessarily limited to: the equalization basins, grit tanks, the primary clarifier distribution chamber, primary clarifiers, aeration basins, secondary distribution chamber, secondary clarifiers, gravity filters, chlorination basin distribution chamber, chlorination basins, gravity thickeners, sludge holding tanks, Blower Building, Disinfection Building, Filter Building, and Primary Treatment Building.

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, compressors, and other remaining equipment shall be made. All systems shall be purged as required. All sumps, tanks, basins, chambers, wet wells, and pipe lines which are hydraulically checked shall be drained and returned to their original condition once the non-potable water testing is complete.

3. All instruments and controls shall be calibrated through their full range. Any 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 wastewater treatment facilities 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. Non-Potable Water Hydraulic Performance

1. As soon as practicable after the wastewater treatment facilities and related systems have been prepared for startup, coordinate with the Engineer and bring the facility on line for a 96 hour (4 continuous 24-hour days) hydraulic performance test. Only clean non-potable water shall be used for this test. During the test period, the successful continuous operation of all systems including but not limited to blowers, pumps, chemical feed systems which can be operated with water under their anticipated normal operating conditions of temperature, pressure, and capacity shall be demonstrated to insure operational reliability, free from leaks, failures, and other defects. Schedule with the Engineer an end to end checkout of all instrumentation and control systems in accordance with their installed loop and ladder diagrams. All required corrections, final adjustments and calibrations shall be made. The intent is to test the entire facility as completely as possible without sewage and sludge.

2. In the event of failure to demonstrate satisfactory performance for 96 continuous operating hours 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

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necessary until the facility has operated continuously to the satisfaction of the Owner and Engineer, for the specified test duration.

3. During the non-potable water hydraulic performance test, and any subsequent retests if required, the Contractor shall be fully responsible for the supervision and operation of all units and systems.

D. Start-up With Raw Sewage and Final Performance Demonstration

1. As soon after the satisfactory completion of the non-potable water hydraulic performance test that the facilities are ready to accept sewage, make the appropriate connections and divert sewage to the new plant facilities. Demonstrate 7 consecutive 24 hour days of successful operation of the facility with raw sewage, as a prerequisite of substantial completion and acceptance.

2. 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.

3. Owner will furnish all operating personnel (other than vendor's or subcontractor's service personnel) needed to operate equipment during the final raw sewage performance 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.

4. At no time during performance tests shall the Contractor allow the facility to be operated in a manner which subjects any equipment to conditions that are more severe than the maximum allowable operating conditions for which the equipment was designed.

5. Startup with sewage and the final performance demonstration shall not begin until all new treatment 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 with raw sewage. All valve tagging as specified in this Section shall also be complete prior to this startup.

E. Refer to Section 01665 for additional requirements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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WARRANTY FOR EQUIPMENT ITEM

LOCATION OF PROJECT: _____
OWNER:
PROJECT NUMBER:
EQUIPMENT ITEM:
SECTION NO. / ITEM NO.:
SUPPLIER:
SUPPLIER'S ADDRESS:

SUPPLIER'S REFERENCE NO.:

The undersigned guarantees that the above equipment is of good merchantable quality, free from defects in material or workmanship, fully meets the type, quality, design and performance requirements defined in the Contract Documents of the above project, and that the equipment will in actual operation satisfactorily perform the functions for which installed.

The undersigned agrees to repair, replace, or otherwise make good, any defect in workmanship or materials in the above described equipment which may develop within a period of one year from the date of final acceptance by the Owner of the above named project.

COMPANY_____

COMPANY ADDRESS_____

_____

BY_____

TITLE_____

SIGNED_____

DATE _____

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EQUIPMENT DATA SHEET

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EQUIPMENT MANUFACTURER'S CERTIFICATE OF INSTALLATION
TESTING AND INSTRUCTION

Client _____

Project _____

Contract No. _____

CDM Smith Proj. No. _____

EQUIPMENT SPECIFICATION SECTION _____

EQUIPMENT DESCRIPTION _____

I_____, Authorized representative of
(Print Name)
_____
(Print manufacturer's name)

hereby CERTIFY that _____
(Print equipment name & model w/serial No.)
_____

installed for the subject project has (have) been installed in a satisfactory manner, has (have) been satisfactorily tested, is (are) ready for operation, and that Owner assigned operating personnel have been suitably instructed in the operation, lubrication, and care of the unit(s)
on Date _____ Time: _____ .

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

OWNER'S ACKNOWLEDGEMENT OF MANUFACTURER'S INSTRUCTION

I (we) the undersigned, authorized representatives of the _-_____
_____ and/or Plant Operating Personnel have received classroom and hands on instruction on the operation, lubrication, and maintenance of the subject equipment and prepared to assume normal operational responsibility for the equipment:

_____ DATE: _____

_____ DATE: _____

_____ DATE: _____

_____ DATE: _____

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SECTION 01300
SUBMITTALS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the requirements for compiling, processing and transmitting submittals required for execution of the project.

B. Submittals are categorized into two types: Action Submittals and Informational Submittals, as follows:

1. Action Submittal: Written and graphic information submitted by the Contractor that requires the Engineer's approval. The following are examples of action submittals:
   a. Shop drawings (including working drawings and product data)
   b. Samples
   c. Operation & maintenance manuals
   d. Site Usage Plan (Contractor's staging - including trailer siting and material laydown area)
   e. Schedule of values
   f. Payment application format
   g. Contractor’s plans for work to be performed as part of an outage (e.g., bypass pumping).

2. Informational Submittal: Information submitted by the Contractor that does not require the Engineer's approval. The following are examples of informational submittals:
   a. Shop Drawing Schedule, including monthly updates
   b. Construction Schedule
   c. Statements of Qualifications
   d. Health and Safety Plans
   e. Construction Photography and Videography
   f. Work Plans
   g. Maintenance of Traffic Plans
   h. Outage Requests
   i. Designs Prepared by Licensed Professional Engineers
   j. Proposed Testing Procedures
   k. Test Records and Reports
   l. Vendor Training Outlines/Plans
   m. Test and Start-Up Reports
   n. Certifications
   o. Record Drawings
   p. Record Shop Drawings
   q. Submittals required by laws, regulations and governing agencies
   r. Submittals required by funding agencies
   s. Other requirements found within the technical specifications
   t. Warranties and Bonds
   u. As-Built Surveys
   v. Contract Close-out Documents

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1.02 RELATED WORK

A. Additional requirements may be specified in the General Conditions for the Contract.

B. Additional submittal requirements may be specified in the respective technical Specification Sections.

C. Applications for Payment are included in Section 01026.

D. Requests for Information are included in Section 01038.

E. Project Controls (Surveying) are included in Section 01050.

F. Construction Schedules are included in Section 01310.

G. Photographic Documentation is included in Section 01322.

H. Contract closeout submittals are included in Section 01700.

I. Project Record Documents are included in Section 01720.

J. Operation and Maintenance manuals are included in Section 01730.

K. Warranties and Bonds are included in Section 01740.

1.03 CONTRACTOR'S RESPONSIBILITIES

A. All submittals shall be clearly identified as follows:

1. Date of Submission.

2. Project Number.

3. Project Name.

4. Contractor Identification.
   a. Contractor.
   b. Supplier.
   c. Manufacturer.
   d. Manufacturer or supplier representative.

5. Identification of the Product.

6. Reference to Contract Drawing (as applicable).

7. Reference to specification section number, page and paragraph(s).

8. Reference to applicable standards, such as ASTM or Federal Standards numbers.

9. Indication of Contractor's approval.

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10. Contractor's Certification statement.

11. Identification of deviations from the Contract Documents, if any.

12. Reference to previous submittal (for resubmittals).

13. Made in America (when required by the Contract).

B. Submittals shall be clear and legible, and of sufficient size for legibility and clarity of the presented data.

C. Submittal Log. Contractor shall maintain a log of all submittals and provide an updated log to the Engineer at least once per month. The submittal log shall be kept accurate and up to date. This log should include the following items (as applicable):

1. Description.

2. Submittal Number.

3. Date transmitted to the Engineer.

4. Date returned to Contractor (from Engineer).

5. Status of Submittal (Approved/Not Approved/etc.).

6. Date of Resubmittal to Engineer and Return from Engineer (if applicable and repeat as necessary).

7. Date material released for fabrication.

8. Projected (or actual) delivery date.

D. Numbering System. Utilize the following submittal identification numbering system:

1. The first character shall be a D, S, M or I which represents Shop Drawing (including working drawings and product data), Sample, Manual (Operating & Maintenance) or Informational, respectively.

2. The next five digits shall be the applicable Section Number.

3. The next three digits shall be the sequential number of each separate item or drawing submitted under each Specification Section, in the chronological order submitted, starting at 001.

4. The last character shall be a letter, A to Z, indicating the submission (or resubmission) of the same submittal, i.e., "A" = 1st submission, "B" = 2nd submission, "C" = 3rd submission, etc. A typical submittal number would be as follows: D-03300-008-B.
   a. D = Shop Drawing;
   b. 03300 = Section for Concrete;
   c. 008 = the eighth different submittal under this Section;
   d. B = the second submission (first resubmission) of that particular shop drawing.

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E. Contractor's Certification

1. Each shop drawing, working drawings, product data, and sample shall have affixed to it the following Certification Statement:

> "Certification Statement: by this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements."

F. Shop drawings, working drawings, and product data sheets 11-in x 17-in and smaller shall be bound together in an orderly fashion and bear the above Certification Statement on the cover sheet. The transmittal cover sheet for each identified shop drawing shall fully describe the packaged data and include a listing of all items within the package.

G. The review and approval of shop drawings, working drawings, product data, or samples by the Engineer shall not relieve the Contractor from the responsibility for the fulfillment of the terms of the Contract. All risks of error and omission are assumed by the Contractor and the Engineer will have no responsibility therefor.

H. Project work, materials, fabrication, and installation shall conform to approved shop drawings (including working drawings and product data) and applicable samples.

I. No portion of the work requiring a shop drawing (including working drawings and product data) or sample shall be started, nor shall any materials be fabricated or installed before approval of such item. Procurement, fabrication, delivery or installation or products or materials that do not conform to approved shop drawings shall be at the Contractor's risk. Furthermore, such products or materials delivered or installed without approved shop drawings, or in non-conformance with the approved shop drawings will not be eligible for progress payment until such time as the product or material is approved or brought into compliance with approved shop drawings. Neither the Owner nor Engineer will be liable for any expense or delay due to corrections or remedies required to accomplish conformity.

J. Professional Engineer (P.E.) Certification Form

1. If specifically required in any of the technical Specification Sections, submit a Professional Engineer (P.E.) Certification for each item required, using the form appended to this Section.

K. Variances

1. Notify the Engineer in writing, at the time of submittal, of any deviations in the submittals from the requirements of the Contract Documents.

2. Notify the Engineer in writing, at the time of re-submittal (resubmission), of all deviations from previous submissions of that particular shop drawing, except those deviations which are the specific result of prior comments from the Engineer.

L. Action Submittals

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1. Shop Drawings, Working Drawings, Product Data and Samples.
   a. Shop Drawings
      1) Shop drawings as defined in the General Conditions, and as specified in individual Sections may include, but are not necessarily limited to, custom prepared data such as fabrication and erection/installation (working) drawings, scheduled information, setting diagrams, actual shop work manufacturing instructions, custom templates, valve schedules, wiring diagrams, coordination drawings, equipment inspection and test reports, and performance curves and certifications, as applicable to the work.
      2) Contractor shall verify all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and coordinate each item with other related shop drawings and the Contract requirements.
      3) All details on shop drawings shall clearly show the relation of the various parts to the main members and lines of the structure and where correct fabrication of the work depends upon field measurements, such measurements shall be made and noted on the drawings before being submitted.
      4) All shop drawings submitted by subcontractors and vendors shall be reviewed by the Contractor. Contractor shall confirm, materials, dimensions, catalog numbers, technical data and performance criteria; and shall coordinate with other related shop drawings and the Contract requirements. In addition, Contractor shall confirm existing field conditions and dimensions and assure that the submittal is coordinated and compatible with existing conditions. Submittals directly from subcontractors or vendors will not be accepted by the Engineer.
      5) The Contractor shall be responsible the accuracy of the subcontractor's or vendor's submittal; and, for their submission in a timely manner to support the requirements of the Contractor's construction schedule. Shop drawings found to be inaccurate or otherwise in error shall be returned to the subcontractor or vendor to correct, before submission to the Engineer. All shop Drawings shall be approved by the Contractor.
      6) Delays to construction due to the untimely submission of submittals will constitute inexcusable delays, for which Contactor shall not be eligible for additional cost nor additional contract time. Inexcusable delays consist of any delay within the Contactor's control.
      7) Submittals for equipment specified under Divisions 11, 13, 14, 15 and 16 shall include a listing of installations where identical or similar equipment manufactured by that manufacturer has been installed and in operation for a period of at least five years.

   b. Working Drawings
      1) Detailed installation drawings (sewers, equipment, piping, electrical conduits and controls, HVAC work, and plumbing, etc.) shall be prepared and submitted for review and approval by the Engineer prior to installing such work. Installation drawings shall be to-scale and shall be fully dimensioned.
      2) Piping working drawings shall show the laying dimensions of all pipes, fittings, valves, as well as the equipment to which it is being connected. In addition, all pipe supports shall be shown.
      3) Equipment working drawings shall show all equipment dimensions, anchor bolts, support pads, piping connections and electrical connections. In addition, show clearances required around such equipment for maintenance of the equipment.

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4) Electrical working drawings shall show conduits, junction boxes, disconnects, control devices, lighting fixtures, support details, control panels, lighting and power panels, and Motor Control Centers. Coordinate all locations with the Contract Documents and the Contractor's other working drawings.

c. Product Data
   1) Product data, as specified in individual Specification Sections, include, but are not limited to, the manufacturer's standard prepared data for manufactured products (catalog data), such as the product specifications, installation instructions, availability of colors and patterns, rough-in diagrams and templates, product photographs (or diagrams), wiring diagrams, performance curves, quality control inspection and reports, certifications of compliance (as specified or otherwise required), mill reports, product operating and maintenance instructions, recommended spare parts and product warranties, as applicable.

2. Samples
   a. Furnish, samples required by the Contract Documents for the Engineer's approval. Samples shall be delivered to the Engineer as specified or directed. Unless specified otherwise, provide at least two samples of each required item. Materials or equipment for which samples are required shall not be used in the work unless and until approved by the Engineer.
   b. Samples specified in individual Specification Sections, include, but are not limited to: physical examples of the work (such as sections of manufactured or fabricated work), small cuts or containers of materials, complete units of repetitively-used products, color/texture/pattern swatches and range sets, specimens for coordination of visual effect, graphic symbols, and other specified units of work.
   c. Approval of a sample shall be only for the characteristics or use named in such approval and shall not be construed to change or modify and Contract Requirements.
   d. Approved samples not destroyed in testing shall be sent to the Engineer or stored at the site of the work. Approved samples of the hardware in good condition will be marked for identification and may be used in the work. Materials and equipment incorporated in work shall match the approved samples. Samples which fail testing or are not approved will be returned to the Contractor at his expense, if so requested at time of submission.

3. Operation and Maintenance Data
   a. Operation and maintenance data shall be submitted in assembled manuals as specified. Such manuals shall include detailed instructions for Owner personnel on safe operation procedures, controls, start-up, shut-down, emergency procedures, storage, protection, lubrication, testing, trouble-shooting, adjustments, repair procedures, and other maintenance requirements of Section 01730.

4. Site Usage
   a. Submit a proposed site staging plan, including but not limited to the location of office trailers, storage trailers and material laydown. Such plan shall be a graphic presentation (drawing) of the proposed locations; and, shall include on-site traffic modifications, and temporary utilities, as may be applicable.

5. Schedule of Values

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a. On projects consisting of lump sums (in whole or in part) submit a proposed schedule of values, in accordance with Section 01370, providing a breakdown of lump sum items in to reasonably small components – generally disaggregated by building, area, and/or discipline. The purpose of the schedule of values is for processing partial payment applications. If requested by the Engineer, provide sufficient substantiation for all or some items as necessary to determine the proposed schedule of values is a reasonable representation of the true cost breakdown of the Work. The schedule of values shall not be unbalanced to achieve early payment or over-payment in excess of the value of work or any other mis-distribution of the costs. If, in the opinion of the Engineer, the schedule of values is unbalanced, Contractor shall reallocate components to achieve a balanced schedule acceptable to Engineer.

6. Payment Application Format
   a. If an application form is included in the Contract Documents, use that form unless otherwise approved by the Engineer and Owner. If an application form is not included in the Contract Documents, Contractor may propose a form for approval, in accordance with Section 01152.

M. Informational Submittals

1. Shop Drawing Schedule
   a. Prepare and submit a schedule indicating when shop drawings are required to be submitted to support the as-planned construction schedule. The submittal schedule shall allow sufficient time for preparation and submittal, review and approval, and fabrication and delivery to support the construction schedule.
   b. Prepare and submit monthly updates to the shop drawing schedule.

2. Construction Schedule
   a. Prepare and submit construction schedules and monthly status reports as specified in Section 01310.

3. Statements of Qualifications
   a. Provide evidence of qualification, certification, or registration, as required in the Contract Documents, to verify qualifications of licensed land surveyor, professional engineer, materials testing laboratory, specialty subcontractor, technical specialist, consultant, specialty installer, and other professionals.

4. Health and Safety Plans
   a. When specified, prepare and submit a general company Health and Safety Plan (HSP), modified or supplemented to include job-specific considerations.

5. Construction Photography and Videography
   a. Provide periodic construction photographs and videography as specified – including but not limited to preconstruction photographs and/or video, monthly progress photos and/or video and post-construction photographs and/or video as specified in Section 01380.

6. Work Plans
   a. Prepare and submit copies of all work plans needed to demonstrate to the Owner that Contractor has adequately thought-out the means and methods of construction and their interface with existing facilities.

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7. Maintenance of Traffic Plans
    a. Prepare maintenance of traffic plans where and when required by the Contract Documents and by local ordinances or regulations. If Contractor is not already knowledgeable about local ordinances and regulations regarding maintenance of traffic requirements, become familiar with such requirements and include all costs for preparation and submittal of traffic management plans and all associated costs for permits and fees to implement the traffic management plan, in the bid amount. In addition, unless a supplemental payment provision is provided in the bid form, include the cost of police attendance, when required.

8. Outage Requests
    a. Provide sufficient notification of any outages required (electrical, flow processes, etc.) as may be required to tie-in new work into existing facilities. Unless specified otherwise elsewhere, a minimum of fourteen calendar days' notice shall be provided.
    b. If the Contractor is to perform work as part of an outage (bypass pumping, etc.), then the Contractor shall submit a detailed work plan as an Action Submittal for review and approval by the Engineer.

9. Designs Prepared by Licensed Professional Engineers
    a. Submit designs that have been prepared by licensed Professional Engineers as specified in the various technical specifications.
    b. Attach the P.E. Certification Form at the end of this Section to each submittal.

10. Proposed Testing Procedures
    a. Prepare and submit testing procedures to be used to perform testing required by the various technical specifications.

11. Test Records and Reports
    a. Provide copies of all test records and reports as specified in the various technical specifications.

12. Vendor Training Outlines/Plans
    a. At least two weeks before scheduled training of Owner's personnel, provide lesson plans for vendor training in accordance with the specification for O&M manuals.

13. Test and Start-up Reports
    a. Manufacturer shall perform all pre-start-up installation inspection, calibrations, alignments, and performance testing as specified in the respective Specification Section. Provide copies of all such test and start-up reports.

14. Certifications
    a. Provide various certifications as required by the technical specifications. Such certifications shall be signed by an officer (of the firm) or other individual authorized to sign documents on behalf of that entity.
    b. Certifications may include, but are not limited to:
        1) Welding certifications and welders qualifications
        2) Certifications of Installation, Testing and Training for all equipment
        3) Material Testing reports furnished by an independent testing firm
        4) Certifications from manufacturer(s) for specified factory testing
        5) Certifications required to indicate compliance with any sustainability or LEEDS accreditation requirements indicated in the Contract Documents

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15. Record Drawings
    a. No later than Substantial Completion, submit a record of all changes during construction not already incorporated into drawings – in accordance with specification on Project Record Documents.

16. Record Shop Drawings
    a. Before final payment is made, furnish one set of record shop drawings to the Engineer. These record shop drawings shall be in conformance with the approved documents and should show any field conditions which may affect their accuracy.

17. Submittals required by laws, regulations and governing agencies
    a. Prepare and submit all documentation required by state or local law, regulation or government agency directly to the applicable agency. This includes, but is not limited to, notifications, reports, certifications, certified payroll (for projects subject to wage requirements) and other documentation required to satisfy all requirements. Provide to Engineer one copy of each submittal made in accordance with this paragraph.

18. Submittals required by funding agencies
    a. Prepare and submit all documentation required by funding agencies. This includes, but is not limited to segregated pay applications and change orders when required to properly allocate funds to different funding sources; and certified payrolls for projects subject to wage requirements. Provide one copy of each submittal made in accordance with this paragraph to the Engineer.

19. Other requirements of the technical Specification Sections
    a. Comply with all other requirements of the technical specifications.

20. Warranties and Bonds
    a. Assemble a booklet or binder of all warranties and bonds as specified in the various technical specifications and in accordance with the specification on Warranties and Bonds; and provide two originals to the Engineer.

21. As-Built Surveys
    a. Engage the services of a licensed land surveyor in accordance with the Project Controls (Surveying) specification. Prior to Final Completion, provide an as-built survey of the constructed facility, as specified.

22. Contract Close-Out Documents
    a. Submit Contract documentation as indicated in the specification for Contract Close-out as specified in Section 01700.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SUBMITTAL SCHEDULE

A. Provide an initial submittal schedule at the pre-construction meeting for review by Owner and Engineer. Incorporate comments from Owner or Engineer into a revised submittal schedule.

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B. Maintain the submittal schedule and provide sufficient copies for review by Owner and Engineer. An up-to-date submittal schedule shall be provided at each project progress meeting.

3.02 TRANSMITTALS

A. Prepare separate transmittal sheets for each submittal. Each transmittal sheet shall include at least the following: the Contractor's name and address, Owner's name, project name, project number, submittal number, description of submittal and number of copies submitted.

B. Submittals shall be transmitted or delivered directly to the office of the Engineer, as indicated in the Contact Documents or as otherwise directed by the Engineer.

C. Provide copies of transmittals forms or cover letters (without attachments) directly to the Resident Project Representative.

3.03 PROCEDURES

A. Action Submittals

1. Contractor's Responsibilities
   a. Coordination of Submittal Times: Prepare and transmit each submittal sufficiently in advance of performing the related work or other applicable activities, or within the time specified in the individual work of other related Sections, so that the installation will not be delayed by processing times including disapproval and resubmittal (if required). Coordinate with other submittals, testing, purchasing, fabrication, delivery and similar sequenced activities. Extensions to the Contract Time will not be approved for the Contractor's failure to transmit submittals sufficiently in advance of the Work.
   b. The submittals of all shop drawings (including working drawings and product data) shall be sufficiently in advance of construction requirements to allow for possible need of re-submittals, including the specified review time for the Engineer.
   c. No less than 30 calendar days will be required for Engineer's review time for shop drawings and O&M manuals involving only one engineering discipline. No less than 45 calendar days will be required for Engineer's review time for shop drawings and O&M manuals that require review by more than one engineering discipline. Resubmittals will be subject to the same review time.
   d. Submittals of operation and maintenance data shall be provided within 30 days of approval of the related shop drawing(s).
   e. Before submission to the Engineer, review shop drawings as follows:
      1) make corrections and add field measurements, as required
      2) use any color for its notations except red (reserved for the Engineer's notations) and black (to be able to distinguish notations on black and white documents)
      3) identify and describe each and every deviation or variation from Contract documents or from previous submissions, except those specifically resulting from a comment from the Engineer on a previous submission
      4) include the required Contractor's Certification statement
      5) provide field measurements (as needed)
      6) coordinate with other submittals
      7) indicate relationships to other features of the Work
      8) highlight information applicable to the Work and/or delete information not applicable to the Work
   f. Submit the following number of copies:

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1) Shop drawings (including working drawings and product data) – Submit no fewer than six, and no more than nine; five of which will be retained by the Engineer.
2) Samples – three
3) Site Usage Plan – three copies
4) Schedule of values – four copies
5) Payment application format – four copies

g. If Contractor considers any correction indicated on the shop drawings to constitute a change to the Contract Documents, provide written notice thereof to the Engineer immediately; and do not release for manufacture before such notice has been received by the Engineer.
h. When the shop drawings have been completed to the satisfaction of the Engineer, carry out the construction in accordance therewith; and make no further changes therein except upon written instructions from the Engineer.

2. Engineer's Responsibilities
   a. Engineer will not review shop drawings (including working drawings and product data) that do not include the Contractor's approval stamp and required certification statement. Such submittals will be returned to the Contractor, without action, for correction.
   b. Partial shop drawings (including working drawings and product data) will not be reviewed. If, in the opinion of the Engineer, a submittal is incomplete, that submittal will be returned to the Contractor for completion. Such submittals may be returned with comments from Engineer indicating the deficiencies requiring correction.
   c. If shop drawings (including working drawings and product data) meet the submittal requirements, Engineer will forward copies to appropriate reviewer(s). Otherwise, noncompliant submittals will be returned to the Contractor without action - with the Engineer retaining one copy.
   d. Submittals which are transmitted in accordance with the specified requirements will be reviewed by the Engineer within the time specified herein. The time for review will commence upon receipt of submittal by Engineer.

3. Review of Shop Drawings (Including Working Drawings and Product Data) and Samples
   a. The review of shop drawings, working drawings, data and samples will be for general conformance with the design concept and Contract Documents. They shall not be construed:
      1) as permitting any departure from the Contract requirements
      2) as relieving the Contractor of responsibility for any errors, including details, dimensions, and materials
      3) as approving departures from details furnished by the Engineer, except as otherwise provided herein
   b. The Contractor remains responsible for details and accuracy, for coordinating the work with all other associated work and trades, for selecting fabrication processes, for techniques of assembly, and for performing work in a safe manner.
   c. If the shop drawings (including working drawings and product data) or samples as submitted describe variations and indicate a deviation from the Contract requirements that, in the opinion of the Engineer are in the interest of the Owner and are so minor as not to involve a change in Contract Price or Contract Time, the Engineer may return the reviewed drawings without noting an exception.
   d. Only the Engineer will utilize the color "RED" in marking submittals.

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e. Shop drawings will be returned to the Contractor with one of the following codes.
   1) Code 1 – "APPROVED" – This code is assigned when there are no notations or comments on the submittal. When returned under this code the Contractor may release the equipment and/or material for manufacture.
   2) Code 2 - "APPROVED AS NOTED" - This code is assigned when a confirmation of the notations and comments IS NOT required by the Contractor. The Contractor may release the equipment or material for manufacture; however, all notations and comments must be incorporated into the final product.
   3) Code 3 - "APPROVED AS NOTED/CONFIRM" - This combination of codes is assigned when a confirmation of the notations and comments is required by the Contractor. The Contractor may release the equipment or material for manufacture; however, all notations and comments must be incorporated into the final product. This confirmation shall specifically address each omission and nonconforming item that was noted. Confirmation is to be received by the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
   4) Code 4 - "APPROVED AS NOTED/RESUBMIT" - This combination of codes is assigned when notations and comments are extensive enough to require a resubmittal of the entire package. This resubmittal is to address all comments, omissions and non-conforming items that were noted. Resubmittal is to be received by the Engineer within 30 calendar days of the date of the Engineer's transmittal requiring the resubmittal.
   5) Code 5 – "NOT APPROVED" – This code is assigned when the submittal does not meet the intent of the contract documents. The Contractor must resubmit the entire package revised to bring the submittal into conformance. It may be necessary to resubmit using a different manufacturer/vendor to meet the requirements of the contract documents.
   6) Code 6 – "COMMENTS ATTACHED" – This code is assigned where there are comments attached to the returned submittal, which provide additional data to aid the Contractor.
   7) Code 7 – "RECEIPT ACKNOWLEDGED (Not subject to Engineer's Review or Approval)" – This code is assigned to acknowledge receipt of a submittal that is not subject to the Engineer's review and approval, and is being filed for informational purposes only. This code is generally used in acknowledging receipt of means and methods of construction work plans, field conformance test reports, and health and safety plans.
   8) Codes 1 through 5 designate the status of the reviewed submittal. Code 6 indicates that some or all of the Engineer’s comments are included in an attachment.

f. Repetitive Reviews: Shop drawings, O&M manuals and other submittals will be reviewed no more than twice at the Owner's expense. All subsequent reviews will be performed at the Contractor's expense. Reimburse the Owner for all costs invoiced by Engineer for the third and subsequent reviews.

4. Electronic Transmission
   a. Action Submittals may be transmitted by electronic means provided the following conditions are met:
      1) The above-specified transmittal form is included.

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2) All other requirements specified above have been met including, but not limited to, coordination by the Contractor, review and approval by the Contactor, and the Contractor's Certification.
3) The submittal contains no pages or sheets large than 11 x 17 inches.
4) The entire submittal is included in a single file.
5) The electronic files are PDF format (with printing enabled).
6) In addition, transmit three hard-copy (paper) originals to the Engineer, if requested.
7) For Submittals that require certification, corporate seal, or professional embossment (i.e., P.E.s, Surveyors, etc.) transmit at least two hard-copy originals to the Engineer. In addition, provide additional photocopied or scanned copies, as specified above, showing the required certification, corporate seal, or professional seal.

B. Informational Submittals

1. Contractor's Responsibilities
   a. Number of copies: Submit three copies, unless otherwise indicated in individual Specification sections
   b. Refer to individual technical Specification Sections for specific submittal requirements.

2. Engineer’s Responsibilities
   a. The Engineer will review each informational submittal within 15 days. If the informational submittal complies with the Contract requirements, Engineer will file for the project record and transmit a copy to the Owner. Engineer may elect not to respond to Contractor regarding informational submittals meeting the Contract requirements.
   b. If an informational submittal does not comply with the Contract requirements, Engineer will respond accordingly to the Contractor within 15 days. Thereafter, the Contractor shall perform the required corrective action, including retesting, if needed, until the submittal, in the opinion of the Engineer, is in conformance with the Contract Documents.

3. Electronic Transmission
   a. Informational submittals may be transmitted by electronic means providing all of the following conditions are met:
      1) The above-specified transmittal form is included.
      2) The submittal contains no pages or sheets large than 11 x 17 inches.
      3) The entire submittal is included in a single file.
      4) The electronic files are PDF format (with printing enabled).
      5) For Submittals that require certification, corporate seal, or professional embossment (i.e., P.E.s, Surveyors, etc.)) transmit two hard-copy originals to the Engineer.

END OF SECTION
(Form Attached)

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P.E. CERTIFICATION FORM

The undersigned hereby certifies that he/she is a professional engineer registered in the State of Tennessee and that he/she has been employed by

_____ to design
(Company Name)

_____
(Insert P.E. Responsibilities)

In accordance with Specification Section _____ for the

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_____.
(Name of Project)

The undersigned further certifies that he/she has performed the said design in conformance with all applicable local, state and federal codes, rules and regulations; and, that his/her signature and P.E. stamp have been affixed to all calculations and drawings used in, and resulting from, the design.

The undersigned hereby agrees to make all original design drawings and calculations available to the

_____
(Insert Name of Owner)

or Owner's representative within seven days following written request therefor by the Owner.

_____	_____
P.E. Name	Company Name
_____	_____
Signature	Signature
_____	_____
P.E. Registration Number	Title

_____
Address

_____
Address

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SECTION 01322
PHOTOGRAPHIC DOCUMENTATION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to provide photographic documentation of the Project as specified herein.

1.02 SUMMARY

A. Section includes administrative and procedural requirements for the following:

1. Aerial and land-based preconstruction photographs.

2. Aerial and land-based periodic construction photographs.

3. Aerial and land-based final completion construction photographs.

4. Preconstruction video recordings.

5. Periodic construction video recordings.

1.03 RELATED WORK

1. Submittal procedures for submitting photographic documentation are included in Section 01300.

2. Videography requirements for operation and maintenance training are included in Section 01664.

1.04 REFERENCES

A. Not Used.

1.05 SUBMITTALS

A. Qualification Data: For photographer and videographer.

B. Key Plan: Submit key plan of Project site and building with notation of vantage points marked for location and direction of each photograph and video recording. Indicate elevation or story of construction. Include same information as corresponding photographic documentation.

C. Digital Photographs (Aerial and land-based): Submit image files within three days of taking photographs. Hard copy photographic prints are not required.

1. File Format: Minimum 3200 by 2400 pixels, in unaltered original files, with same aspect ratio as the sensor, uncropped, date and time stamped, in folder named by date of photograph, accompanied by key plan file.

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2. Submit digital photographs in data disc format acceptable to Engineer.
   a. Full-size (12-cm / 4.7-inch diameter) CD-R, DVD-R and DVD+R single-use recordable discs are acceptable.
   b. No other disc types (including but not limited to CD-RW, DVD-RW, or any 8-cm / 3.1-inch diameter Mini CD or DVD) or storage media (including but not limited to USB drives) will be accepted.
   c. Package each disc in a hard plastic case, clearly and indelibly labeled using self-adhesive labels specifically designed for labeling of discs. Include on the label the project name, project number, and the time period covered by the photographs contained on the disc.

3. Identification: Provide the following information with each image description in file metadata tag:
   a. Name of Project.
   b. Name and contact information for photographer.
   c. Name of Engineer.
   d. Name of Contractor.
   e. Date and time photograph was taken.
   f. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
   g. Unique sequential identifier keyed to accompanying key plan.

D. Video Recordings: Submit video recordings within seven days of recording.

1. Submit video recordings in digital video disc format acceptable to Engineer.
   a. Full-size (12-cm / 4.7-inch diameter) CD-R, DVD-R and DVD+R single-use recordable discs are acceptable.
   b. No other disc types (including but not limited to CD-RW, DVD-RW, or any 8-cm / 3.1-inch diameter Mini CD or DVD) or storage media (including but not limited to USB drives) will be accepted.
   c. Package each disc in a hard plastic case, clearly and indelibly labeled using self-adhesive labels specifically designed for labeling of discs. Include on the label the project name, project number, and the time period covered by the video recordings contained on the disc.

2. Identification: With each submittal, provide the following information:
   a. Name of Project.
   b. Name and contact information for videographer.
   c. Name of Engineer.
   d. Name of Contractor.
   e. Date video recording was recorded.
   f. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
   g. Weather conditions at time of recording.

3. Transcript: Prepared on 8-1/2-by-11-inch (215-by-280-mm) paper, punched and bound in heavy-duty, three-ring, vinyl-covered binders. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as corresponding video recording. Include Project name, Project number, and date of video recording on each page.

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1.06 QUALITY ASSURANCE

A. Photographer Qualifications: An individual who has been regularly engaged as a professional photographer of construction projects for not less than three years.

B. Videographer Qualifications: An individual who has been regularly engaged as a professional videographer of construction projects for not less than three years.

1.07 USAGE RIGHTS

A. Obtain and transfer copyright usage rights from photographer and videographer to Owner for unlimited reproduction of photographic documentation.

PART 2 PRODUCTS

2.01 PHOTOGRAPHIC MEDIA

A. Digital Photographs:

1. Provide digital photographs produced by a dedicated, fixed- or interchangeable-lens digital camera. Images made with cell phones, tablets, webcams, and wearable cameras are not acceptable.

2. Digital Camera: Have a minimum image resolution of 8megapixels, and produce images in JPEG (.JPG) format with image dimensions of not less than 3200 by 2400 pixels.

B. Digital Video Recordings:

1. Provide video recordings made with a dedicated digital video camera specifically made for video recordings. Video recordings made with cell phones, tablets, webcams, and wearable cameras are not acceptable.

2. Digital Video Camera: Have a minimum resolution of 720p (1280 x 720, progressive).

3. Provide video recordings in a common digital video format such as .MP4 or .WMV. The minimum resolution of all video files shall be 720p (1280 x 720, progressive). Submit video files on a digital video disc in format acceptable to Engineer.

PART 3 EXECUTION

3.01 CONSTRUCTION PHOTOGRAPHS

A. Photographer: Engage a qualified photographer to take construction photographs.

B. General: Take photographs that clearly show the Work. Exhibit correct exposure and focus, accurate color balance, maximum depth of field, minimal optical distortion, and minimal noise. Photographs that, in the Engineer's opinion, do not meet these quality criteria will not be accepted and shall be re-taken at no additional cost to the Owner.

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1. Maintain key plan with each set of construction photographs that identifies each photographic location.

C. Digital Images: Submit digital images exactly as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software.

1. Date and Time: Include date and time in file name for each image.

2. Field Office Images: Maintain one set of images accessible in the field office at Project site, available at all times for reference. Identify images in the same manner as those submitted to Engineer.

D. Aerial Photographs:

1. Provide aerial photography of the entire project site. Do not extend limits past the project boundary in order to provide the greatest level of detail of the entire work area.

2. Provide three different views at the following periods of the Project.
   a. Prior to commencement of the Work.
   b. Each month of construction.
   c. At project completion.

3. A total of [insert number] aerial photographs are required.

E. Preconstruction Photographs: Before starting construction, take photographs of Project site and surrounding properties, including existing items to remain during construction, from different vantage points, as directed by Engineer.

1. Flag construction limits before taking construction photographs.

2. Take 20 photographs to show existing conditions adjacent to property before starting the Work.

3. Take 20 photographs of existing buildings either on or adjoining property to accurately record physical conditions at start of construction.

4. Take additional photographs as required to record settlement or cracking of adjacent structures, pavements, and improvements.

F. Periodic Construction Photographs: Take 20 photographs monthly, coinciding with the cutoff date associated with each Application for Payment. Select vantage points to show status of construction and progress since last photographs were taken.

G. Final Completion Construction Photographs: Take 20 color photographs after date of Substantial Completion for submission as project record documents. Engineer will inform photographer of desired vantage points.

H. Additional Photographs: Engineer may request photographs in addition to periodic photographs specified. Additional photographs will be paid for by Change Order and are not included in the Contract Sum.

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1. Three days' notice will be given, where feasible.

2. In emergency situations, take additional photographs within 24 hours of request.

3. Circumstances that could require additional photographs include, but are not limited to, the following:
   a. Special events planned at Project site.
   b. Immediate follow-up when on-site events result in construction damage or losses.
   c. Photographs to be taken at fabrication locations away from Project site. These photographs are not subject to unit prices or unit-cost allowances.
   d. Substantial Completion of a major phase or component of the Work.
   e. Extra record photographs at time of final acceptance.
   f. Owner's request for special publicity photographs.

3.02 CONSTRUCTION VIDEO RECORDINGS

A. Videographer: Engage a qualified videographer to record construction video recordings.

B. Video Recordings:

1. Produce bright, clear, sharp pictures with accurate colors and free from distortion, excessive shake, or any other form of picture imperfection. The audio track of each video recording shall reproduce precise and concise explanatory notes by the camera operator with proper volume, clarity and freedom from distortion and interference. Video recordings that, in the Engineer’s opinion, do not meet these quality criteria will not be accepted and shall be re-recorded at no additional cost to the Owner.

2. Mount camera on tripod before starting recording unless otherwise necessary to show area of construction. Display continuous running time and date. At start of each video recording, record weather conditions from local newspaper or television and the actual temperature reading at Project site.

C. Narration: Describe scenes on video recording by audio narration by microphone while recording, or by dubbing audio narration off-site afterwards. Include description of items being viewed, recent events, and planned activities. At each change in location, describe vantage point, location, direction (by compass point), and elevation or story of construction.

1. Confirm date and time at beginning and end of recording.

2. Begin each video recording with name and number of Project, Contractor's name, videographer's name, and Project location.

D. Transcript: Provide a typewritten transcript of the narration. Display images and running time captured from video recording opposite the corresponding narration segment.

E. Preconstruction Video Recording: Before starting construction, record video recording of Project site and surrounding properties from different vantage points, as directed by Engineer.

1. Flag construction limits before recording construction video recordings.

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2. Show existing conditions adjacent to Project site before starting the Work.

3. Show existing buildings either on or adjoining Project site to accurately record physical conditions at the start of construction.

4. Show protection efforts by Contractor.

END OF SECTION

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SECTION 01445
PIPE TESTING, CLEANING AND DISINFECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the general requirements for testing and cleaning the various buried and non-buried piping systems shown on the Drawings and as specified herein.

B. Disinfect all potable water lines as specified herein.

1.02 RELATED WORK

A. Pipe, joints, piping systems and appurtenances are specified in other Sections of Divisions 2 and 15.

B. Testing of plumbing piping systems is included in Section 15410.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, a complete description of testing and disinfection methods and procedures. The procedures shall include a plan for disposal of testing and disinfection fluids. The Contractor shall submit his plan for testing to the Engineer for review and coordination at least 10 days prior to the proposed test date.

B. Test Records

1. Records shall be maintained of all tests performed.

2. Test records shall include:

   a. Date of Testing
   b. Identification of Piping Tested
   c. Test Fluid
   d. Test Pressure
   e. Signature of Contractor

3. If leaks are found, they shall be noted, on the record. After correction, retesting as specified for original test.

4. Records of test shall be maintained by the Contractor and 4 copies furnished to the Engineer.

1.04 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI B31 - Code for Pressure Piping, B31 Interpretation.

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B. American Water Works Association (AWWA)

1. AWWA C600 – Installation of Ductile Iron Water Mains and their Appurtenances

2. AWWA C651 – Disinfecting Water Mains

3. AWWA M12 – Simplified Procedures for Water Examination

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

1.05 TEST PRESSURES

A. Unless otherwise specified in Paragraph 1.05B, the following test pressures shall apply to each type of test:

1. Hydrostatic Test – Test pressure shall be 150 percent of the maximum design pressure.

2. Service Pressure Test – Test pressure shall be the maximum pressure that the line will be subjected to under normal operating conditions as determined by the Engineer.

3. Pneumatic Test for Process Air Piping & Secondary Containment Piping – Test pressures shall be 110 percent of the anticipated maximum operating pressure, but shall not exceed 100 psig nor be less than 5 psig at the highest point in the system.

4. Air Test for Gravity Sewers and Gravity Drains – The pipeline being tested shall be pressurized to 4 psig. The line will be allowed to stabilize between 4 psig and 3.5 psig for a period of no less than 5 minutes.

B. Test pressures and the tests performed on each piping system shall be as follows. "None" indicates that the test is not to be performed on a particular piping system (e.g., pneumatic testing is not to be performed on plastic piping except for secondary containment piping).

Piping System	Pipe Material	Test Pressure (psig), Temperature (deg. F)[1] & Duration (hours)			
		Hydrostatic Test	**Service Pressure Test**	**Pneumatic Test**	**Air Test for Gravity Sewers & Drains**
Chemical Piping	PVC & CPVC	50 psig 2 hours[2]	None	None	None
Gravity Drains & Vents	PVC	15 psig 2 hours	None	None	None
Gravity Sewers & Gravity Drains	DIP	None	None	None	Refer to Paragraph 3.05

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Piping System	Pipe Material	Test Pressure (psig), Temperature (deg. F)[1] & Duration (hours)			
		Hydrostatic Test	Service Pressure Test	Pneumatic Test	Air Test for Gravity Sewers & Drains
Odor Control Air Piping	FRP & HDPE	None	None	10 psig 2 hours	None
Potable & Plant Water Piping	DIP & Copper	250 psig 2 hours	None	None	None
Process Wastewater Piping Between Structures	DIP	None	None	None	Refer to Paragraph 3.05
Pressure Wastewater & Sludge Piping	DIP	125 psig 2 hours	None	None	None
Process Air Piping	SS	None	None	30 psig 2 hours	None
Sump Pump Discharge Piping	PVC	20 psig 2 hours	None	None	None

Notes:
1. If a test temperature is not specified in the table, then the test shall be performed at ambient temperature.
2. See Section 15064 for additional requirements for testing of chemical piping.

PART 2 PRODUCTS

2.01 TEST FLUIDS

A. Hydrostatic Test - Water should be used as the test fluid whenever possible. In those systems where water cannot be used the test fluid may be either the one to be used in the system or the one agreed upon by the Engineer and the Contractor.

B. Service Pressure Test - The fluid for which the system is designed shall be the test fluid.

C. Pneumatic Test - Compressed air shall normally be used. Other gases may be used when specified or directed by the Engineer. Test pressures shall be 110 percent of the anticipated maximum operating pressure, but not exceeding 100 psig, and not less than 5 psig at the highest point in the system.

D. Air Test – Compressed air shall be used.

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2.02 TEST EQUIPMENT

A. Hydrostatic Test

1. Water - Of sufficient capacity to deliver the required test pressure.

2. Strainer - On inlet side of the pump to prevent foreign matter from entering the system.

3. Valves - Shall be provided on the suction and discharge side of the pump.

4. Heater - To allow heating of the test fluid when elevated temperatures are required for test.

5. Relief Valve - Set at a pressure to relieve at 20 to 25 percent above the required test pressure.

6. Pressure Gauge(s) - Capable of reaching 50 percent over the test pressure. These should be located at the pump discharge and any other place deemed convenient by the Contractor.

7. Pressure gauges and relief valves shall be checked for accuracy before use in test procedures.

B. Service Pressure Test

1. A pressure gauge capable of registering 25 psi over the design pressure shall be installed down-stream from the supply shut-off valve if one is not included in the system.

C. Pneumatic Test for Process Air Lines

1. Building supply air to deliver the required test pressure if available, or provide a compressor capable of the required test pressure.

2. Valves shall be provided on the discharge side of the pump.

3. Relief valve to relieve at 10 to 15 percent over the test pressure.

4. Pressure gauge(s) capable of reaching 50 percent over the test pressure. A gauge shall be located on the pump discharge and other location as required.

D. Air Test for Gravity Sewers and Gravity Drains

1. Air compressor capable of the required test pressure.

2. Valves shall be provided on the discharge side of the pump.

3. Pressure Gauge(s) – 0 – 10 psi range with minimum divisions of 0.10 psi, and an accuracy of +/- 0.04 psi.

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PART 3 EXECUTION

3.01 GENERAL

A. Upon completion of designated treatment facilities and appurtenances and all their related systems, the Contractor shall submit start-up plans, including test methods and pressures, to the Engineer for review and coordination. The Contractor must submit his plan for testing to the Engineer for review and coordination at least 10 days prior to the proposed test date.

B. All tests shall be performed under the direct supervision of the Contractor and in the presence of the Engineer.

C. The Engineer shall be notified at least 24 hours before each test is performed.

D. Restrict personnel in the test area to those involved in the test.

E. Safety glasses and hard hats must be worn throughout testing.

F. Furnish all necessary equipment and labor for cleaning, testing and disinfecting the piping systems. The Engineer shall approve the procedures and methods.

G. Make any taps and furnish all necessary caps, plugs, etc, as required in conjunction with testing piping systems. Furnish a test pump, gauges and any other equipment required in conjunction with carrying out the hydrostatic tests.

H. Prior to testing, the pipelines shall be supported in an approved manner to prevent movement during the tests.

I. All leaks shall be repaired and leakage eliminated regardless of the total leakage as shown by test.

J. Water for Testing

1. Plant water may be used for yard pipe testing, pump testing, etc., but not for dust control or other uses that would discharge the plant water on the ground.
    a. Any water used for testing shall be discharged into the sewer line to the beginning of the plant. Discharge of plant water into the storm drain or into the river or drained onto the surface of the ground is expressly prohibited.
    b. Connections to the plant water system may be made at existing yard hydrants or the Contractor may tap a larger plant water line and set up a dedicated connection for construction/testing use. Tapping of the main shall be made only with the approval of the Engineer and Owner. There will be no charge for the water, however the Contractor shall be responsible for all equipment, facilities, etc. needed to obtain and transport the water.
    c. The Contractor shall also be responsible for equipment and facilities necessary to deliver and maintain the desired test pressures.
    d. The Contractor shall coordinate the use of plant water with the Engineer and Owner to ensure that plant water supply to the treatment process is not interrupted.

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2. Potable water may be used for yard pipe testing, pump testing etc, as well as for dust control and other uses where the water could be discharged to the ground.
   a. Any water used for testing may be discharged into the sanitary sewer system. Discharge into a storm drain or into the river is NOT approved unless authorized by the Engineer.
   b. The Contractor will be responsible for payment of all fees and charges for potable water use. All potable water use will be metered, and the Contractor shall make application with the Owner for rental of a meter and backflow preventer for installation at the connection to the potable water source. If meters are to be in service for an extended period of time, then the meter and backflow preventer will be returned to the Owner at the one-year anniversary for collection of usage fee and renewal of the rental. Fee will be based on residential service and calculated at the fee schedule in effect at the time of payment.
   c. The Contractor shall be responsible for all equipment, facilities, etc. needed to obtain and transport the water.
   d. Connections to the potable water system shall be at locations approved by the Engineer and the Owner.

3.02 CLEANING PIPELINES

A. As pipe laying progresses and at the conclusion of the work, thoroughly clean all new pipelines by flushing with water or other means to remove all dirt, stones, pieces of wood or other material which may have entered during the construction period. If, after this cleaning, obstructions remain, they shall be removed.

3.03 HYDROSTATIC TEST

A. This test shall be used to hydrostatically test piping systems for structural integrity and leaks. Hydrostatic pressure testing and leakage testing shall conform to AWWA C600 with the exception that the Contractor shall furnish all gauges, meters, pressure pumps and other equipment necessary to test the line.

B. The test shall be performed at ambient temperature unless otherwise specified.

C. Preparation for Test

1. Determine the fluid to be used for the test, and, if other than ambient temperature is required, what the test temperature will be. All potable water used for flushing and testing shall be metered at the location(s) as directed by the Owner and through tap(s) provided at the Contractor's expense in accordance with the Owner's policies.

2. When a fluid other than water is used for a test, the equipment used for the test shall be of a material compatible with the test fluid. Normally this would be equal to the piping material.

3. Vents shall be provided at the high points of the system and drains provided where means of venting or draining do not exist.

4. Remove or block off, all relief valves, rupture discs, alarms, control instruments, etc, that shall not be subjected to the test pressure.

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5. All discs, balls, or pistons from check valves shall be removed if they interfere with filling of the system. Open all valves between inlet and outlet of the section to be tested.

6. Connect pump and provide temporary closures for all of the external openings in the system. Use caution to insure that the closures are properly designed and strong enough to withstand the test pressure.

7. All joints, including welds, are to be left uninsulated and exposed for examination during test.

8. A joint previously tested in accordance with this specification may be covered or insulated.

9. Piping designed for vapor or gas shall be provided with additional temporary supports, if necessary, to support the weight of the test liquid.

10. Expansion joints shall be provided with temporary restraint for additional pressure under test or shall be isolated from the test.

11. Flanged joints, where blanks are inserted to isolate equipment during the test, need not be tested.

C. The hydrostatic test pressure shall be 150 percent of the maximum design pressure unless otherwise specified in Paragraph 1.05B.

D. Test Procedures

1. At no time are valves on the supply system to be operated without the presence of a duly qualified representative of the Owner.

2. Allow the test fluid to enter the system. Open vents to allow displacement of all entrapped air. For all pipelines exceeding 500-ft in length, the maximum rate of filling shall be limited to that which produces a maximum nominal flow velocity of one foot per second in the pipe to be tested.

3. Upon completion of the filling process, the system shall be brought up to the specified test temperature as applicable, holding the system pressure to less than 10 percent of the test pressure.

4. Close vents and restrict personnel in the test area to those involved in the test.

5. Raise the pressure slowly with the pump until the predetermined test pressure is reached. The pipe should be slowly brought up to the test pressure in such a manner so as to not create shock, surge or water hammer in the pipe system. Maintain pressure for duration of time specified in Paragraph 1.05B, keeping personnel at a safe distance.

4. The amount of leakage that shall be permitted shall be in accordance with AWWA C600.

5. Reduce the pressure about 20 percent and hold it at that point while the entire system is carefully inspected for leaks, cracks, or other signs of defects.

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6. If defects are found, the pressure shall be released, the system drained, the defects corrected and the test repeated.

7. After a satisfactory test has been completed, the line shall be drained.

E. Flushing

1. Lines tested with water shall be completely drained.

2. Lines shall be flushed, after test.

3.04 SERVICE PRESSURE TEST

A. This test shall be used to test piping systems using service pressure and the fluid for which the system is used. It shall not be used to test piping systems conveying combustible or flammable liquids or systems that comply with ANSI B31 codes. Insulated lines shall have all joints left exposed until completion of the test.

B. The test pressure shall be equal to the maximum pressure that the line will be subjected to under normal operating conditions as determined by the Engineer unless otherwise stated in Paragraph 1.05B.

C. Test Procedures

1. Liquids

a. See that all personnel not involved in the test vacate the area.

b. Allow the system fluid to enter the system slowly while venting the air at the extreme far and uppermost points. For all pipelines exceeding 500-ft in length, the maximum rate of filling shall be limited to that which produces a maximum nominal flow velocity of one foot per second in the pipe to be tested.

c. When the system is full and all air is vented, close the vents.

d. Allow the pressure in the system to build up to the full line pressure.

e. Inspect entire system for leaks.

2. Gas or Vapor (Including Compressed Air and Steam)

a. See that all personnel not involved in the test vacate the area.

b. In systems that do not have a pressure gauge near the main shut-off valve, a gauge shall be installed.

c. Allow the system fluid to enter the system slowly until the full operating pressure is reached.

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d. Shut off main supply valve. Observe the gauge for 15 minutes. The pressure gauge shall not drop during this time.

e. If the gauge drops, indicating the presence of leaks, the systems shall be inspected visually and, if necessary, with soap suds or commercially available leak detectors to locate the leak(s).

3. If leaks are found, the lines shall be relieved of pressure, purged if necessary and repaired. Tests shall be repeated for repaired sections.

3.05 PNEUMATIC TEST FOR PROCESS AIR PIPING & SECONDARY CONTAINMENT PIPING

A. This procedure for a pneumatic test of piping systems shall be used when directed by the ENGINEER when water, or other liquid, cannot be introduced into the line, or as a supplement to a hydrostatic test. This test shall not be used to test non-metallic (plastic) pipe.

B. Safety

1. All pneumatic tests shall be done under the supervision of Contractor and in the presence of the Engineer.

2. New Construction: The Engineer's permission shall be secured before testing.

3. Renovation Projects: The Owner representative and the Engineer must be informed and their permission secured before testing.

4. Only those people actively participating in the test shall be allowed in the test area.

5. Safety glasses and hard-hats must be worn.

C. Test Procedures

1. Increase the pressure in the line gradually, in steps, to the specified pressure. Checks shall be made at 25 psig and at 5 psig intervals until the test pressure is reached using sound, soap solution or a drop in indicated pressure.

2. When the specified pressure for the test is reached, shut off the valve in the supply line from the pump.

3. Maintain the test pressure long enough to visually inspect all joints or a minimum of 10 minutes. There shall be no drop in the test pressure in this time.

4. Leaks shall be repaired and the line retested. All leaks shall be noted on the Test Record form.

5. After satisfactory completion of the test, vent the line and allow it to return to atmospheric pressure. Connection can then be made to the supply line.

3.06 LOW PRESSURE AIR TEST FOR GRAVITY SEWERS AND GRAVITY DRAINS

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A. This procedure for an air test of gravity piping systems shall be used when directed by the Engineer. Low pressure air tests shall be made with equipment specifically designed and manufactured for the purpose of testing pipelines using low pressure air. The equipment shall be provided with an air regulator valve or air safety valve so set that the internal air pressure in the pipeline cannot exceed 8 psig. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be tested. All air used shall pass through a single control panel.

B. Preparation for Test

1. The line shall be sealed at each end. Service lines shall be capped securely at the tee connection. The seal at one end shall have an orifice through which to pass air into the pipe. An air supply shall be connected to the orifice. The air supply line will contain an on/off valve and pressure gauge.

C. Test Procedure

1. The pipeline being tested shall be pressurized to 4 psig. The line will be allowed to stabilize between 4 psig and 3.5 psig for a period of no less than 5 minutes. If necessary, air should be added to the line to maintain pressure above 3.5 psig. After the stabilization period, the valve shall be closed. When the line pressure drops to 3.5 psig, timing with a stop watch should begin. The stop watch shall run until the pressure drops to 2.5 psig. Then the stop watch shall be stopped and the time lapse compared with the allowable time lapse in the table below for the pipe size and leakage allowance specified by the Engineer.

2. If the time lapse is greater than that specified, the section being tested shall have passed, and the tests may be discontinued. If the time lapse is less than that specified, the line has not passed the test and the Contractor will be required to repair the line until it does pass the test.

3. Air Leakage Chart

Size of Pipe (inches)	Minutes: Seconds per 100 ft.
4	1:00
6	1:00
8	1:30
10	2:00
12	2:30
18	3:00
24	4:00
36	6:00
54	8:00

4. If the pipeline to be tested is beneath the groundwater level, the test pressure shall be increased 0.433 psi for each foot the groundwater level is above the invert of the pipe.

5. The Contractor will be required to test lines while construction is in progress and before the pipe laying is completed to ascertain compliance. Any visible or audible leaks in the sewer

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that can be located shall be repaired or corrected as directed by the Engineer, regardless of test results.

3.06 DISPOSAL OF TEST FLUIDS

A. Refer to Paragraph 3.01J.

B. Debris in the water shall be removed prior to discharge.

3.07 DISINFECTION OF POTABLE WATER PIPING SYSTEMS

A. Upon completion of the pressure and leakage test, the section of pipe to be disinfected shall be initially flushed using potable water. Flushing shall be accomplished at a minimum velocity of 2.5 feet per second and shall continue until the water runs clear.

B. Disinfection shall be accomplished by the continuous feed chlorination method in accordance with AWWA C651. The following steps shall be employed:

1. Begin filling main at a constant, measured rate with potable water. As water first flows in, begin adding chlorine at a point no more than ten feet from the beginning of the new main.

2. Add chlorine at a rate to attain a 25 mg/L chlorine concentration. The acceptable method is by preparing a 1% solution with sodium hypochlorite or calcium hypochlorite. The required amount of chlorine to produce a 25 mg/L concentration in 100 feet of pipe is as follows:

Pipe Diameter	100% Chlorine (lb)	1% Chlorine Solutions (gal.)
4	0.013	0.16
6	0.030	0.36
8	0.054	0.65
10	0.085	1.02
12	0.120	1.44
16	0.217	2.60
18	0.275	3.30
20	0.339	4.06
24	0.488	5.85

3. Continue adding chlorine at a rate to attain a minimum concentration of 25 mg/L. Measure the rate at regular intervals as given in AWWA M12 or with a high range test kit. Chlorine application shall continue until the entire main is filled.

4. The chlorinated water shall be retained in the water main for a minimum of 24 hours. At the end of the 24 hour period the water in all portions of the main shall have a minimum chlorine residual of 10 mg/L.

C. The heavily chlorinated water shall be dechlorinated and flushed in a manner that is not detrimental to the environment. The method proposed shall be submitted to and approved by

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the Engineer prior to discharge. Final flushing shall continue until the chlorine residual is less than 2 mg/L.

D. Contractor shall coordinate sampling with the Owner, following authorization by the Engineer. No earlier than 16 hours after final flushing, the Owner will obtain bacteriological samples for testing.

E. If the Owner's bacteriological test results are unsatisfactory, the main shall either be flushed with potable water or re-disinfected by the Contractor, as directed by the Engineer, prior to obtaining additional samples. Satisfactory bacteriological test results shall be obtained prior to placing the new main in service. The disinfection process will be repeated by the Contractor at no cost to the Owner until satisfactory results are obtained.

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SECTION 01600
DELIVERY, STORAGE AND HANDLING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the general requirements for the delivery handling, storage and protection for all items required in the construction of the work. Specific requirements, if any, are specified with the related item.

1.02 TRANSPORTATION AND DELIVERY

A. Transport and handle items in accordance with manufacturer's instructions.

B. Schedule delivery to reduce long term on-site storage prior to installation and/or operation. Under no circumstances shall equipment be delivered to the site more than one month prior to installation without written authorization from the Engineer.

C. Coordinate delivery with installation to ensure minimum holding time for items that are hazardous, flammable, easily damaged or sensitive to deterioration.

D. Deliver products to the site in manufacturer's original sealed containers or other packing systems, complete with instructions for handling, storing, unpacking, protecting and installing.

E. All items delivered to the site shall be unloaded and placed in a manner which will not hamper the Contractor's normal construction operation or those of subcontractors and other contractors and will not interfere with the flow of necessary traffic.

F. Provide necessary equipment and personnel to unload all items delivered to the site.

G. Promptly inspect shipment to assure that products comply with requirements, quantities are correct and items are undamaged. For items furnished by others (i.e., Owner, other Contractors), perform inspection in the presence of the Engineer. Notify Engineer verbally, and in writing, of any problems.

H. If any item has been damaged, such damage shall be repaired at no additional cost to the Owner.

1.03 STORAGE AND PROTECTION

A. Store and protect products in accordance with the manufacturer's instructions, with seals and labels intact and legible. Storage instruction shall be studied by the Contractor and reviewed with the Engineer by him/her. Instruction shall be carefully followed and a written record of this kept by the Contractor. Arrange storage to permit access for inspection.

B. Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter.

C. Cement and lime shall be stored under a roof and off the ground and shall be kept completely dry at all times. All structural, miscellaneous and reinforcing steel shall be stored off the ground

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or otherwise to prevent accumulations of dirt or grease and in a position to prevent accumulations of standing water and to minimize rusting. Beams shall be stored with the webs vertical. Precast concrete shall be handled and stored in a manner to prevent accumulations of dirt, standing water, staining, chipping or cracking. Brick, block and similar masonry products shall be handled and stored in a manner to reduce breakage, cracking and spalling to a minimum.

D. All mechanical and electrical equipment and instruments subject to corrosive damage by the atmosphere if stored outdoors (even though covered by canvas) shall be stored in a weathertight building to prevent injury. The building may be a temporary structure on the site or elsewhere, but it must be satisfactory to the Engineer. Building shall be provided with adequate ventilation to prevent condensation. Maintain temperature and humidity within range required by manufacturer.

1. All equipment shall be stored fully lubricated with oil, grease and other lubricants unless otherwise instructed by the manufacturer.

2. Moving parts shall be rotated a minimum of once weekly to ensure proper lubrication and to avoid metal-to-metal "welding". Upon installation of the equipment, the Contractor shall start the equipment, at least half load, once weekly for an adequate period of time to ensure that the equipment does not deteriorate from lack of use.

3. Lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment at the time of acceptance.

4. Prior to acceptance of the equipment, the Contractor shall have the manufacturer inspect the equipment and certify that its condition has not been detrimentally affected by the long storage period. Such certifications by the manufacturer shall be deemed to mean that the equipment is judged by the manufacturer to be in a condition equal to that of equipment that has been shipped, installed, tested and accepted in a minimum time period. As such, the manufacturer will guarantee the equipment equally in both instances. If such a certification is not given, the equipment shall be judged to be defective. It shall be removed and replaced at the Contractor's expense.

E. All paint and other coating products shall be stored in areas protected from the weather. Follow all storage requirements set forth by the paint and coating manufacturers.

1.04 SPARE PARTS

A. Where spare parts are specified in the technical Sections, furnish all spare parts recommended by the manufacturer or system supplier. In addition, furnish all spare parts itemized in each Section. Manufacturers and suppliers may be required to provide spare parts recommended for the initial year of operation.

B. Spare parts shall be collected and stored as required by the manufacturers in accordance with this Section. Spare parts shall be packed in cartons, properly labeled with indelible markings that allow identification of the contents without opening the packaging. Labeling shall include complete descriptive information including the manufacturer, part number, part name, and

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equipment for which the part is to be used. Parts shall be suitably protected for long-term storage in a humid environment.

C. An inventory listing all spare parts, the equipment they are associated with, the name and address of the supplier, and the delivered cost of each item shall be provided to the Engineer. Copies of actual invoices for each item shall be furnished with the inventory to substantiate the delivered cost.

D. Collect and store spare parts in an area to be designated by the Engineer. Spare parts shall be treated as stored materials and shall be the responsibility of the Contractor until start-up is complete.

E. Spare parts shall be delivered to the Owner prior to start-up, but no sooner than ten days prior to start-up.

F. Spare parts shall be subject to the one-year warranty period effective after project acceptance.

1.05 SPECIAL TOOLS

A. Manufacturers of equipment and machinery shall furnish any special tools (including grease guns or other lubricating devices) required for normal adjustment, operations and maintenance, together with instructions for their use. Preserve and deliver to the Owner these tools and instructions in good order no later than ten days prior to start-up of the equipment.

B. Tools shall be furnished in heavy steel tool chests complete with lock and duplicate keys. Chests shall be indelibly marked on the exterior to indicate the equipment for which the tools are intended.

1.06 GREASE, OIL AND FUEL

A. All grease, oil and fuel required for testing of equipment shall be furnished with the respective equipment. The Owner shall be furnished with a year's supply of required lubricants, including grease and oil of the type recommended by the manufacturer, with each item of equipment supplied under Divisions 2, 11, 13, 14, 15 and 16.

B. Lubricants in all drives and intermediate drives of mechanical equipment shall be changed after initial break-in of the equipment, which in no event shall be any longer than three weeks of operation.

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SECTION 01664
OPERATION & MAINTENANCE TRAINING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for training the Owner's personnel, by persons retained by the Contractor specifically for the purpose, in the proper operation and maintenance of the equipment and systems installed under this contract.

1.02 RELATED WORK

A. Submittals are included in Section 01300.

B. Photographic Documentation, which includes video recordings, is included in Section 01322.

1.03 SUBMITTALS

A. The following information shall be submitted to the Engineer in accordance with the provisions of Section 01300. The material shall be reviewed and accepted by the Engineer as a condition precedent to receiving progress payments in excess of 75 percent of the contract amount and not less than ten weeks prior to the provision of training.

1. A training outline that provides a brief description of the subject matter, delivery method and learning objectives that will be delivered for classroom and hands-on training sessions identified in Paragraph 3.01C.

2. Lesson plans for each training session to be conducted by the manufacturer's representatives. In addition, training manuals, handouts, visual aids, and other reference materials shall be included.

3. Subject of each training session, identity and qualifications of individuals to be conducting the training, and tentative date and time of each training session.

1.04 QUALITY ASSURANCE

A. Where required by the detailed specifications, the Contractor shall provide on-the-job training of the Owner's personnel. Qualified, experienced, factory-trained representatives of the various equipment manufacturers shall conduct the training sessions. Training shall include instruction in both operation and maintenance of the subject equipment.

B. Videographer Qualifications: An individual who has been regularly engaged as a professional videographer of operation and maintenance training for not less than three years.

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PART 2 PRODUCTS

2.01 GENERAL

A. Where specified, the Contractor shall conduct training sessions for the Owner's personnel to instruct the staff on the proper operation, care, and maintenance of the equipment and systems installed under this contract. Training shall take place at the site of the work and under the conditions specified in the following paragraphs. Approved operation and maintenance manuals shall be available at least 30 days prior to the date scheduled for the individual training session. Training sessions shall be scheduled at the convenience of the Owner.

B. LOCATION & TIME

1. Training sessions shall take place at the site of the work at the Franklin WRF in Franklin, Tennessee.

2. The Contractor shall arrange to have the training conducted on consecutive days, with no more than six hours of classes scheduled for any one day. Concurrent classes shall not be allowed.

2.02 LESSON PLANS

A. Formal written lesson plans shall be prepared for each training session. Lesson plans shall contain an outline of the material to be presented along with a description of visual aids to be utilized during the session. Each plan shall contain a time allocation for each subject.

B. One complete set of originals of the lesson plans, training manuals, handouts, visual aids, and reference material shall be the property of the Owner and shall be suitably bound for proper organization and easy reproduction. The Contractor shall furnish twelve copies of necessary training manuals, handouts, visual aids and reference materials at least one week prior to each training session.

2.03 FORMAT AND CONTENT

A. Each training session shall be comprised of time spent both in the classroom and at the specific location of the subject equipment or system. As a minimum, training session shall cover the following subjects for each item of equipment or system:

1. Familiarization
   a. Review catalog, parts lists, drawings, etc., which have been previously provided for the plant files and operation and maintenance manuals.
   b. Check out the installation of the specific equipment items.
   c. Demonstrate the unit and indicate how all parts of the specifications are met.
   d. Answer questions.

2. Safety
   a. Using material previously provided, review safety references.
   b. Discuss proper precautions around equipment.

3. Operation
   a. Using material previously provided, review reference literature.

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b. Explain all modes of operation (including emergency).
c. Check out Owner's personnel on proper use of the equipment.

4. Preventive Maintenance
   a. Using material previously provided, review preventative maintenance (PM) lists including:
      1) Reference material
      2) Daily, weekly, monthly, quarterly, semiannual, and annual jobs.
   b. Show how to perform PM jobs.
   c. Show Owner's personnel what to look for as indicators of equipment problems.

5. Corrective Maintenance
   a. List possible problems.
   b. Discuss repairs -- point out special problems.
   c. Open up equipment and demonstrate procedures, where practical.

6. Parts
   a. Show how to use previously provided parts list and order parts.
   b. Check over spare parts on hand. Make recommendations regarding additional parts that should be available.

7. Local Representatives
   a. Where to order parts: Name, address, telephone.
   b. Service problems:
      1) Who to call.
      2) How to get emergency help.

8. Operation and Maintenance Manuals
   a. Review any other material submitted.
   b. Update material, as required.

2.04 VIDEO RECORDING

A. The Contractor shall retain the services of a commercial videography service to record each training session. After recording, the material shall be edited and supplemented with professionally produced graphics to provide a permanent record.

B. The Contractor shall advise all manufacturers providing training sessions that video recordings will be made of the material. The Contractor shall provide from each manufacturer a letter or other written document releasing the County for unlimited use of such video recordings.

C. Technical Requirements

1. Produce bright, clear, sharp pictures with accurate colors and free from distortion, excessive shake, or any other form of picture imperfection. The audio track of each video recording shall reproduce precise and concise explanatory notes by the presenter with proper volume, clarity and freedom from distortion and interference. Video recordings that, in the Engineer's opinion, do not meet these quality criteria will not be accepted and shall be re-recorded at no additional cost to the Owner.

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2. For best quality, training sessions shall be recorded with a dedicated digital video camera specifically made for video recordings. Video recordings made with cell phones, tablets, webcams, and wearable cameras are not acceptable.

3. All video recordings shall be made by a digital video camera with a minimum resolution of 720p (1280 x 720, progressive).

D. Preparation of Training Video Submittals

1. Submit video recordings in digital video disc format acceptable to Engineer.
   a. Full-size (12-cm / 4.7-inch diameter) CD-R, DVD-R and DVD+R single-use recordable discs are acceptable.
   b. No other disc types (including but not limited to CD-RW, DVD-RW, or any 8-cm / 3.1-inch diameter Mini CD or DVD) or storage media (including but not limited to USB drives) will be accepted.
   c. Package each disc in a hard plastic case, clearly and indelibly labeled using self-adhesive labels specifically designed for labeling of discs. Include on the label the project name, project number, and the equipment specification number and description of the equipment. Permanently inserted in the storage case of each video disc shall be a typed index of that disc's contents.

2. All video files shall be a common digital video format such as .MP4 or .WMV. The minimum resolution of all video files shall be 720p (1280 x 720, progressive). Video file names shall include the video recording index number that corresponds to the index specified in Paragraph 2.04D.1.c above.

3. Releases entitling the Owner to unlimited use of the training video recordings shall be included in each submittal. The submittal will not be considered complete without this documentation.

PART 3 EXECUTION

3.01 GENERAL

A. Training shall be conducted in conjunction with the operational testing and commissioning periods. Classes shall be scheduled such that classroom sessions are interspersed with field instruction in logical sequence. Training shall be certified on Form 11000-B a copy of which is provided at the end of this section.

The THP System Supplier's Representative shall present the O&M training to plant staff for all pieces of equipment that make up the THP system OR the representative shall acquire the services of the individual equipment manufacturer's representative to conduct O&M training for their specific equipment supplied.Additionally, the THP System Supplier's Representative shall conduct training on the operation of the overall THP system.

1. For equipment specified in Divisions 11, 13, 14, 15 and 16, training shall be performed after the equipment has been installed, tested, adjusted, and placed in satisfactory operating condition.
   a. The instruction periods shall be scheduled at a time mutually agreed upon with the Owner. Multiple training sessions (a minimum of six) shall be provided for each piece of equipment. The training sessions shall be scheduled to cover all three shifts.

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b. Provide a minimum of not less than eighteen (18) hours divided into a minimum of three (3), six (6) hour sessions for this instruction for each piece of equipment or set of identical pieces of equipment provided unless otherwise specified.
   1) These sessions shall be on consecutive days but staggered times in order to facilitate training of all 3 shifts of Franklin's personnel.
   2) Additional days shall be provided if called for in the individual equipment specification.
   3) Each manufacturer shall include this service in the price of his equipment.
c. The manufacturer's representatives shall fully instruct the Owner's personnel regarding use and maintenance of the equipment.
d. During this instruction period, it shall be the responsibility of the manufacturer's representative to answer all questions from the Owner's operating personnel.

2. The training on the operation of the overall THP system shall focus on the basic operations of the THP system as a whole, and what role each piece of equipment plays in the overall system. The focus should be on operation, maintenance and optimization of the whole THP system, not individual equipment.
   a. Provide a minimum of not less than thirty-six (36) hours divided into a minimum of six (6), six (6) hour sessions (two 6-hour sessions per shift) for the instruction of the operation of the overall THP system.

B. Operation and maintenance manuals approved by the Engineer for the specific equipment shall be provided to the Owner prior to the start of any training. Video recording shall take place concurrently with all training sessions.

C. The following services shall be provided for each item of equipment or system as required in individual specification sections. Additional services shall be provided, where specifically required in individual specification sections.

1. As a minimum classroom equipment training for operations personnel will include:
   a. Using slides and drawings, discuss the equipment's specific location in the plant and an operational overview, emphasizing its interrelationship with other equipment and plant operations.
   b. Purpose and plant function of the equipment.
   c. A working knowledge of the operating theory of the equipment.
   d. Startup, shutdown, normal operation, and emergency operating procedures, including a discussion on system integration and electrical interlocks, if any.
   e. Identify and discuss safety items and procedures.
   f. Routine preventative maintenance, including specific details on lubrication and maintenance of corrosion protection of the equipment and ancillary components.
   g. Operator detection, without test instruments, of specific equipment trouble symptoms.
   h. Required equipment exercise procedures and intervals.
   i. Routine disassembly of equipment if applicable (as judged by the Owner on a case-by-case basis) for purposes such as operator inspection of equipment.

2. As a minimum, hands-on equipment training for operations personnel will include:
   a. Identify location of equipment and review the purpose.
   b. Identifying piping and flow options.
   c. Identifying valves and their purpose.
   d. Identifying instrumentation:

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1) Location of primary element.
2) Location of instrument readout.
3) Discuss purpose, basic operation, and information interpretation.

e. Discuss, demonstrate, and perform standard operating procedures and round checks.
f. Discuss and perform the preventative maintenance activities.
g. Discuss and perform startup and shutdown procedures.
h. Perform the required equipment exercise procedures.
i. Perform routine disassembly and assembly of equipment if applicable.
j. Identify and review safety items and perform safety procedures, if feasible.

3. Classroom equipment training for the maintenance and repair personnel will include:
   a. Theory of operation.
   b. Description and function of equipment.
   c. Startup and shutdown procedures.
   d. Normal and major repair procedures.
   e. Equipment inspection and troubleshooting procedures including the use of applicable test instruments and the "pass" and "no pass" test instrument readings.
   f. Routine and long-term calibration procedures.
   g. Safety procedures.
   h. Preventative maintenance such as lubrication; normal maintenance such as belt, seal, and bearing replacement; and up to major repairs such as replacement of major equipment part(s) with the use of special tools, bridge cranes, welding jigs, etc.

4. Hands-on equipment training for maintenance and repair personnel shall include:
   a. Locate and identify equipment components.
   b. Review the equipment function and theory of operation.
   c. Review normal repair procedures.
   d. Perform startup and shutdown procedures.
   e. Review and perform the safety procedures.
   f. Perform Owner approved practice maintenance and repair job(s), including mechanical and electrical adjustments and calibration and troubleshooting equipment problems.

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11000-B. MANUFACTURER'S INSTRUCTION CERTIFICATION FORM

CONTRACT NO.: _____ SPECIFICATION SECTION: ____

EQUIPMENT NAME: _____

CONTRACTOR: _____

MANUFACTURER OF EQUIPMENT ITEM: _____

The undersigned manufacturer certifies that a service engineer has instructed the water reclamation facility's operation personnel in the proper maintenance and operation of the equipment designated herein.

Operations Check List (check appropriate spaces)

Start-up procedure reviewed	_____
Shutdown procedure reviewed	_____
Normal operation procedure reviewed	_____
Others: _____	_____
_____	_____

Maintenance Check List (check appropriate spaces)

Described normal oil changes (frequency)	_____
Described special tools required	_____
Described normal items to be reviewed for wear	_____
Described preventive maintenance instructions	_____
Described greasing frequency	_____
Others: _____	_____
_____	_____

_____	_____
Date	Manufacturer
_____	_____
Date	Signature of Authorized Representative
_____	_____
Date	Signature of Owner's Representative
_____	_____
Date	Signature of Contractor's Representative

END OF SECTION

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SECTION 01665
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 11, 13, 14, 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. Special Project Procedures are included in Section 01100.

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

C. Performance and acceptance testing and startup requirements are included in the respective sections of Divisions 11, 13, 14, 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.

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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 appended to Section 01100.

1.04 REFERENCE STANDARDS

A. ASTM International

B. American Water Works Association (AWWA)

C. Water Environment Federation (WEF)

D. 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. Following the inspection, the technician shall submit a fully completed Certificate of Installation, provided in Section 01100, to the Engineer.

B. 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.

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C. 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.

D. 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 THE TREATMENT PLANT AND RELATED 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 an equipment system, all work related to that system shall be cleaned and made ready to be put into operation. Any leakage testing required shall be performed and repairs made as required.

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, compressors, 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.

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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 treatment 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 with raw water. 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. Vertical Shaft Mixers
   c. Chemical Feed and Chemical Storage Systems
   d. Odor Control System
   e. Ultraviolet Treatment Equipment
   f. Jet Mixing System
   g. Non-Clog Wastewater Pumps
   h. Grit Collection and Classification Equipment
   i. Screenings Washing and Compacting Equipment
   j. Centrifugal Blowers
   k. Coarse Bubble Diffused Aeration System
   l. All Pumping Equipment
   m. HVAC

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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.

END OF SECTION

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SECTION 01730
OPERATION AND MAINTENANCE DATA SUBMITTALS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section includes procedural requirements for compiling and submitting operation and maintenance data required to complete the project.

1.02 RELATED WORK

A. Submittals are included in Section 01300.

B. Operation & Maintenance Training is included in Section 01664.

C. Warranties and Bonds are included in Section 01740.

1.03 OPERATING MANUALS

A. Provide specific operation and maintenance instructions for all electrical, mechanical, and instrumentation & controls equipment furnished under various technical specification Sections.

B. A separate manual shall be provided for each type of equipment, or each Section number. Each manual shall contain the following:

1. Format and Materials
   a. Binders:
      1) Commercial quality three ring binders with durable and cleanable plastic covers
      2) Maximum ring width capacity: 3 inches
      3) When multiple binders are used, correlate the data into related consistent groupings/volumes.
   b. Identification: Identify each volume on the cover and spine with typed or printed title "OPERATING AND MAINTENANCE INSTRUCTIONS". Include the following:
      1) Title of Project.
      2) Identify the general subject matter covered in the manual.
      3) Identify structure(s) and/or location(s), of the equipment provided.
      4) Specification Section number.
   c. 20 lb loose leaf paper, with hole reinforcement
   d. Page size: 8-1/2 inch by 11 inch
   e. Provide heavy-duty fly leafs (section separators), matching the table of contents, for each separate product, each piece of operating equipment, and organizational sections of the manual.
   f. Provide reinforced punched binder tab; bind in with text.
   g. Reduce larger drawings and fold to the size of text pages - but not larger than 11 inches x 17 inches - or provide a suitable clear plastic pocket (with drawing identification) for such folded drawings/diagrams.

2. Contents:

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a. A table of contents/Index, divided into section reflective of the major components provided.
b. Completed Mechanical and Electrical Equipment Nameplate Data Sheets for each piece of equipment covered in the manual. Blank Equipment Data Sheets are included in Appendix B at the end of this Section.
c. Specific description of each system and components.
d. Name, address, telephone number(s) and e-mail address(es) of vendor(s) and local service representative(s).
e. Specific on-site operating instructions (including starting and stopping procedures).
f. Safety considerations.
g. Project specific operational procedures and recommended log sheet(s).
h. Project specific maintenance procedures.
i. Manufacturer's operating and maintenance instructions – specific to the project.
j. Copy of each wiring diagram.
k. Copy of approved shop drawing(s) and Contractor's coordination/layout drawing(s).
l. List of spare parts and recommended quantities.
m. Product Data: Mark each sheet to clearly identify specific products and component parts and data applicable to installation. Delete inapplicable information.
n. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams.
o. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified.
p. Warranties and Bonds, as specified in the General Conditions.

3. Transmittals
   a. Prepare separate transmittal sheets for each manual. Each transmittal sheet shall include at least the following: the Contractor's name and address, Owner's name, project name, project number, submittal number, description of submittal and number of copies submitted.
   b. Submittals shall be transmitted or delivered directly to the office of the Engineer, as indicated in the Contact Documents or as otherwise directed by the Engineer.
   c. Provide copies of transmittals (only, i.e., without copies of the respective submittal) directly to the Resident Project Representative.

C. Manuals for Equipment and Systems - In addition to the requirements listed above, for each System, provide the following:

1. Overview of system and description of unit or system and component parts. Identify function, normal operating characteristics and limiting conditions. Include legible performance curves, with engineering data and tests and complete nomenclature and commercial number of replaceable parts.

2. Panelboard circuit directories including electrical service characteristics, controls and communications and color-coded wiring diagrams as installed.

3. Operating procedures: include start-up, break-in and routine normal operating instructions and sequences; regulation, control, stopping, shut-down and emergency instructions; and summer, winter and any special operating instructions.

4. Maintenance Requirements

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a. Procedures and guides for trouble-shooting; disassembly, repair, and reassembly instructions.
b. Alignment, adjusting, balancing and checking instructions.
c. Servicing and lubrication schedule and list of recommended lubricants.
d. Manufacturer's printed operation and maintenance instructions.
e. Sequence of operation by instrumentation and controls manufacturer.
f. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.

5. Control diagrams by controls manufacturer as installed (as-built).

6. Contractor's coordination drawings, with color coded piping diagrams, as installed (as-built).

7. Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams. Include equipment and instrument tag numbers on diagrams.

8. List of original manufacturer's spare parts and recommended quantities to be maintained in storage.

9. Test and balancing reports, as required.

10. Additional Requirements as specified in individual product specification.

11. Design data for systems engineered by the Contractor or its Suppliers.

D. Electronic Transmission of O&M Manuals

1. Unless otherwise approved by the Engineer, O&M manuals may not be transmitted by electronic means other than by CD-ROM or USB flash drive and must be submitted in addition to a hardcopy manual. Electronic O&M manuals shall meet the following conditions:
   a. The above-specified transmittal form is included.
   b. All other requirements specified above have been met, including, but not limited to, coordination by the Contractor, review and approval by the Contractor.
   c. The submittal contains no pages or sheets large than 11 x 17 inches.
   d. With the exception of the transmittal sheet, the entire submittal is included in a single file.
   e. Files are Portable Document Format (PDF) – with the printing function enabled.
   f. All scanned manufacturer's O&M manuals must be quality checked after scanning to ensure the pages are not crooked, all pages are present and complete, and all information is legible.

2. When electronic copies are provided, transmit two hard copy (paper) originals to the Engineer with an electronic copy on CD-ROM.

3. The electronic copy of the O&M manual must be identical in organization, format and content to the hard copies of the manual.

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4. The electronic O&M Manual must be bookmarked identically to the paper manual table of contents to allow quick access to information. Electronic submittals that require extensive scrolling will not be accepted. The document must be indexed and searchable.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SUBMITTAL SCHEDULE

A. Operation and maintenance manuals shall be delivered directly to the office of the Engineer, as follows:

1. Provide preliminary copies of each manual to the office of the Engineer, no later than 30 days following approval of the respective shop drawings.

2. Provide final copies of each completed manual prior to testing.

3. Provide a letter that grants the Engineer and Owner to the limited right to use and reproduce each manual (in it its entirety or any portion thereof) from the respective equipment manufacturer(s). Such limited right shall allow the Engineer and Owner to use each manual or and portion thereof for:
   a. The potential assembly of a comprehensive facility operation and maintenance manual for the sole benefit of the Owner; and
   b. supplemental training of the Owner's personnel and operators, over and above the required vendor's training, regarding operation of the facility as a system.

B. The Engineer will review Operation and Maintenance manuals submittals for operating equipment for conformance with the requirements of the applicable specification Section. The review will generally be based on the O&M Manual Review Checklist attached to this Section as Appendix A.

C. If during test and start-up of equipment, any changes were made to the equipment, provide two hard copies of as-built drawings or any other amendments for insertion, by the contractor, in the previously transmitted final manuals. In addition, provide one revised electronic version including the as-built drawings and any other amendments. The manuals shall be completed, including updates, if any, within 30 days of start-up and testing of the facility.

3.02 VENDOR TRAINING/INSTRUCTIONS (TO OWNER'S PERSONNEL)

A. Refer to Section 01664.

3.03 VIDEOGRAPHY OF VENDOR TRAINING/INSTRUCTION

A. Refer to Section 01664.

END OF SECTION
(Appendices Follow)

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APPENDIX A
O&M MANUAL REVIEW CHECKLIST

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O&M Manual Review Checklist

Submittal No.: _____
Project No.: _____
Manufacturer: _____
Equipment Submitted: _____
Specification Section: _____
Date of Submittal: _____

	General Data	
1.	Are the area representative's name, address, e-mail address and telephone number included?	
2.	Is the nameplate data for each component included?	
3.	Are all associated components related to the specific equipment included?	
4.	Is non-pertinent data crossed out or deleted?	
5.	Are drawings neatly folded and/or inserted into packets?	
6.	Are all pages properly aligned and scanned legibly?	
7.	Is the .PDF document bookmarked according to the table of contents?	
	Operations and Maintenance Data	
8.	Is an overview description of the equipment and/or process included?	
9.	Does the description include the practical theory of operation?	
10.	Does each equipment component include specific details (design characteristics, operating parameters, control descriptions, and selector switch positions and functions)?	
11.	Are alarm and shutdown conditions specific to the equipment provided on this project clearly identified? Does it describe possible causes and recommended remedies?	
12.	Are step procedures for starting, stopping, and troubleshooting specific to the equipment provided included?	
13.	Is a list of operational parameters to monitor and record specific to the equipment provided included?	
14.	Is a proposed operating log sheet specific to the equipment provided included?	
15.	Is a spare parts inventory list included for each component?	
16.	Is a lubrication schedule for each component specific to the equipment provided included - or does it clearly state “No Lubrication Required"?	
17.	Is a maintenance schedule for each component specific to the equipment provided included?	
18.	Is a copy of the warranty information included?	

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Review Comments

Is the submittal fully approved (yes/no)? _____

If not, the following points of rejection must be addressed and require resubmittal by the Contractor:

Item No.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14, _____
15. _____

Reviewed By: _____ Date: _____

Legend

1 = OK

2 = Not Adequate

3 = Not Included

Note: This submittal has been reviewed for compliance with the Contract Documents.

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APPENDIX B
EQUIPMENT NAMEPLATE DATA SHEETS

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MECHANICAL EQUIPMENT NAMEPLATE DATA SHEET

EQUIPMENT NAME	LOCATION

SUPPLIER DATA

MANUFACTURER	VENDOR
Name: Address: Phone: Fax: Website:	Name: Address: Phone: Fax: Sales Rep. Phone: Fax: email:

MECHANICAL EQUIPMENT DATA

Equipment ID:
Tag No.:
Model:
Type:
Serial No.:
Capacity
Ratio:

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ELECTRICAL EQUIPMENT NAMEPLATE DATA SHEET

EQUIPMENT NAME	LOCATION

SUPPLIER DATA

MANUFACTURER	VENDOR
Name: Address: Phone: Fax: Website:	Name: Address: Phone: Fax: Sales Rep. Phone: Fax: email:

ELECTRICAL EQUIPMENT DATA

Equipment ID:
Tag No.:
Model:
Type:
Serial No.:
Amps:
Frame:
Horsepower:
Phase:
RPM:
Hertz:
Volts:
Service Factor:

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SECTION 01740
WARRANTIES AND BONDS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies general administrative and procedural requirements for warranties and bonds required by the Contract Documents, including manufacturer's standard warranties on products and special warranties.

1.02 RELATED WORK

A. Refer to Conditions of Contract for the general requirements relating to warranties and bonds.

B. General closeout requirements are included in Section 01700 Project Closeout.

C. Specific requirements for warranties for the work and products and installations that are specified to be warranted are included in the individual Sections.

1.03 SUBMITTALS

A. Submit written warranties to the Owner prior to the date fixed by the Engineer for Substantial Completion. If the Certificate of Substantial Completion designates a commencement date for warranties other than the date of Substantial Completion for the work, or a designated portion of the work, submit written warranties upon request of the Owner.

B. When a designated portion of the work is completed and occupied or used by the Owner, by separate agreement with the Contractor during the construction period, submit properly executed warranties to the Owner within 15 days of completion of that designated portion of the Work.

C. When a special warranty is required to be executed by the Contractor, or the Contractor and a subcontractor, supplier or manufacturer, prepare a written document that contains appropriate terms and identification, ready for execution by the required parties. Submit a draft to the Owner for approval prior to final execution.

D. Refer to individual Sections for specific content requirements, and particular requirements for submittal of special warranties.

E. At Final Completion compile two copies of each required warranty and bond properly executed by the Contractor, or by the Contractor, subcontractor, supplier, or manufacturer. Organize the warranty documents into an orderly sequence based on the table of contents of the Project Manual.

F. Bind warranties and bonds in heavy-duty, commercial quality, durable 3-ring vinyl covered loose-leaf binders, thickness as necessary to accommodate contents and sized to receive 8-1/2-in by 11-in paper.

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G. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Project Manual, with each item identified with the number and title of the Section in which specified and the name of the product or work item.

H. Provide heavy paper dividers with celluloid covered tabs for each separate warranty. Mark the tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address and telephone number of the installer, supplier and manufacturer.

I. Identify each binder on the front and the spine with the typed or printed title "WARRANTIES AND BONDS", the project title or name and the name, address and telephone number of the Contractor.

J. When operating and maintenance manuals are required for warranted construction, provide additional copies of each required warranty, as necessary, for inclusion in each required manual.

1.04 WARRANTY REQUIREMENT

A. Related Damages and Losses: When correcting warranted work that has failed, remove and replace other work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted work.

B. Reinstatement of Warranty: When work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

C. Replacement Cost: Upon determination that work covered by a warranty has failed, replace or rebuild the work to an acceptable condition complying with requirements of Contract Documents. The Contractor is responsible for the cost of replacing or rebuilding defective work regardless of whether the Owner has benefited from use of the work through a portion of its anticipated useful service life.

D. Owner's Recourse: Written warranties made to the Owner are in addition to implied warranties, and shall not limit the duties, obligations, rights and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitations on time in which the Owner can enforce such other duties, obligations, rights, or remedies.

E. Rejection of Warranties: The Owner reserves the right to reject warranties and to limit selections to products with warranties not in conflict with requirements of the contract Documents.

F. Disclaimers and Limitations: Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the work that incorporates the products, nor does it relieve suppliers, manufacturers and subcontractors required to countersign special warranties with the Contractor.

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1.05 MANUFACTURERS CERTIFICATIONS

A. Where required, the Contractor shall supply evidence, satisfactory to the Engineer, that the Contractor can obtain manufacturers' certifications as to the Contractor's installation of equipment.

1.06 DEFINITIONS

A. Standard Product Warranties are preprinted written warranties published by individual manufacturers for particular products and are specifically endorsed by the manufacturer to the Owner.

B. Special Warranties are written warranties required by or incorporated in the Contract Documents, either to extend time limits provided by standard warranties or to provide greater rights for the Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 09901
SURFACE PREPARATION AND SHOP PRIME PAINTING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required for the surface preparation and application of shop primers on ferrous metals, excluding stainless steels, as specified herein.

1.02 RELATED WORK

A. Finish painting is included in Section 09902.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, shop drawings, manufacturer's specifications and data on the proposed primers and detailed surface preparation, application procedures and dry mil thicknesses.

B. Submit representative physical samples of the proposed primers, if required by the Engineer.

1.04 REFERENCE STANDARDS

A. The Society for Protective Coatings (SSPC)

1. SSPC-SP 6/NACE No. 3 - Joint Surface Preparation Standard SSPC-SP 6/NACE No. 3: Commercial Blast Cleaning

2. SSPC-SP 10/NACE No. 2 - Joint Surface Preparation Standard SSPC-SP 10/NACE No. 2: Near-White Blast Cleaning.

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

PART 2 PRODUCTS

2.01 MATERIALS

A. Submerged Surfaces - Shop primer for ferrous metals which will be in contact with water being treated, either submerged or which are subject to splash action or which are specified to be considered submerged service shall be shop primed with the following:

1. Shop Prime Coat: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
   a. TNEMEC: Series 1 Omnithane
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc.
   d. PPG PMC Durathane MCZ 97-679 Series or PPG PMC Amerlock 400.
   e. Or equal.

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B. Non-Submerged Surfaces: Shop primer for ferrous metals which will not be in contact with water being treated, not submerged and not subject to splash action shall be shop primed with the following:

1. Shop Prime Coat: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
   a. TNEMEC: Series 1 Omnithane
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc.
   d. PPG PMC Durathane MCZ 97-679 Series or PPG PMC Amercoat 68HS
   e. Or equal.

C. Submerged Surfaces:

1. Shop Prime Coat for Ductile Iron Pipe: (Epoxy, Polyamidoamine Shop Primer)
   a. TNEMEC: Series N140 Pota-Pox-Plus
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Macropoxy 846 NSF Winter Grade Epoxy Mill White
   d. PPG PMC Aquapon HB Potable Water Epoxy Coating 95-132 Series or PPG PMC Amerlock 2 Epoxy.
   e. Or equal.

2. Shop Prime Coat for Ferrous Metal Surfaces: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
   a. TNEMEC: Series 1 Omnithane
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc.
   d. PPG PMC Durathane MCZ 97-679 Series
   e. Or equal.

D. Non-Primed Surfaces - Gears, bearings surfaces and other similar surfaces obviously not to be painted shall be given a heavy shop coat of grease or other suitable rust-resistant coating. This coating shall be maintained as necessary to prevent corrosion during all periods of storage and erection and shall be satisfactory to the Engineer up to the time of the final acceptance test.

E. Compatibility of Coating Systems - Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with their corresponding primers and finish coats specified in Section 09902 for use in the field and which are recommended for use together.

PART 3 EXECUTION

3.01 APPLICATION

A. Surface Preparation and Priming

1. Non-submerged components scheduled for priming, as defined above, shall be blast cleaned in accordance with SSPC-SP 6/NACE No. 3, immediately prior to priming. Submerged components scheduled for priming, as defined above, shall be blast cleaned in accordance with SSPC-SP 10/NACE No. 2 , immediately prior to priming. Consult manufacturer regarding required surface profiles.

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2. Surfaces shall be dry and free of dust, oil, grease and other foreign material before priming.

3. Shop prime in accordance with approved manufacturer's recommendations.

B. Non-Primed Surfaces

1. Apply approved coating per manufacturer's recommendations.

3.02 FABRICATED ITEMS

A. All items to be shop primed shall be blast cleaned as specified for applicable service prior to priming. If, in the opinion of the Engineer, any prime coating that has been improperly applied or if material contrary to this Section has been used, that coating shall be removed by abrasive blasting to white metal and reprimed in accordance with this Section.

B. All shop prime coats shall be of the correct materials and applied in accordance with this Section. Remove any prime coats not in accordance with this Section by blast cleaning and apply the specified prime coat at no additional cost to the Owner.

C. Shop primed surfaces shall be cleaned thoroughly and damaged or bare spots prepared as approved and retouched with the specified primer before the application of successive paint coats in the field.

D. Shop finish coats, if proposed and allowed, shall be equal in appearance and protection quality to a field applied finish coat. If, in the opinion of the Engineer, a shop finish coat system does not give the appearance and protection quality of other work of similar nature, prepare the surfaces and apply the coat or coats of paint as directed by the Engineer to accomplish the desired appearance and protection quality. Submit to the Engineer substantial evidence that the standard finish is compatible with the specified finish coat.

E. Properly protect the shop prime and finish coats against damage from weather or any other cause.

F. Wherever fabricated equipment is required to be blast cleaned, protect all motors, drives, bearings, gears, etc, from the entry of grit. Equipment found to contain grit shall be promptly and thoroughly cleaned.

END OF SECTION

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SECTION 09902
FIELD PAINTING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all materials, labor, equipment and incidentals required and perform all the painting necessary to complete this Contract in its entirety as specified herein.

B. It is the intent of this Section to paint all exposed structural and miscellaneous steel; steel doors; steel door and glazed opening frames, chemical tanks and systems; mechanical and electrical equipment; sluice gates, operators and posts; conveying systems, pipe, fittings and valves; electrical conduit and appurtenances; metal deck ceilings; CMU walls; ducts where scheduled; all as specified in the attached painting schedules and all other work obviously required to be painted unless otherwise specified. Minor items not mentioned in the schedule of work shall be included in the work of this Section where they come within the general intent of this Section as stated herein.

C. Paint items so noted in Paragraph 1.01B and in accordance with the Paint Color Schedule. Provide vinyl film letters and numbers for markings as specified. Items noted in Paint Color Schedule as having factory finish and other factory finished items obviously are not field painted. The Contractor is responsible for having damaged factory finish painted items repaired or, if so ordered, for replacing items. The various Sections are responsible, as stated in each, for preparation and field touch-up of abrasions, welds and damaged primed areas of primed or galvanized components after erection.

D. The following items will not be painted:

1. Concrete (unless otherwise specified in the painting schedules).

2. Exterior masonry, split face CMU, ground face CMU

3. Finish hardware unless specifically noted otherwise.

4. Non-ferrous metals and stainless steels, unless specifically noted otherwise.

5. Factory prefinished architectural components.

6. Packing glands and other adjustable parts and name plates of mechanical equipment.

7. Parts of buildings not exposed to sight, unless specifically noted otherwise.

8. Maintenance equipment

9. Plumbing fixtures

10. Mechanical and electrical equipment which has been finished painted in the factory as specified in Divisions 11, 13, 14, 15 and (16.

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1.02 RELATED WORK

A. Shop priming and surface preparation of equipment and piping (except copper piping) are specified in Section 09901 and included in the respective Section with the item to be primed.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300.

B. Product Data: For each type of product indicated. Include preparation requirements and application instructions.

C. Samples: For each type of coating system and in each color and gloss of topcoat indicated.

1. Color cards for initial color selections.

2. Three sets of 8-in by 8-in samples, on 1/4-in hardboard, of all colors required for all types of paint. Include special colors as required. Resubmit until approved.

D. Product List: For each product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.

2. VOC content.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ATSM D 6386 - Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

B. California Department of Health Services

1. Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.

C. Code of Federal Regulations

1. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings

D. The Society for Protective Coatings (SSPC)

1. SSPC SP-1 - Solvent Cleaning.

2. SSPC SP-2 - Hand Tool Cleaning.

3. SSPC SP-7 - Brush-off Blast Cleaning-NACE No. 4

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4. SSPC SP-11 - Power Tool Cleaning to Bare Metal

5. SSPC SP-13 - Surface Preparation of Concrete-NACE No. 6

6. ICRI Technical Guideline No. 03732 - Selecting and Specifying Concrete Surface Preparation for Coatings, Sealers, and Polymer Overlays

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 DELIVERY, STORAGE AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 degrees F.

1. Maintain containers in clean condition, free of foreign materials and residue.

2. Remove rags and waste from storage areas daily.

1.06 FIELD CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are between 50 and 95 degrees F.

B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 degrees F above the dew point; or to damp or wet surfaces.

C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 PRODUCTS

2.01 MATERIALS

A. All painting materials shall be by the Tnemec Company, Inc.; equals by and, where scheduled, NSF Standard 61 certified equals by The Sherwin-Williams Company; PPG Architectural Finishes, Inc. (Ameron) or equal. The painting schedule has been prepared on the basis of Tnemec products (unless otherwise noted) and Tnemec recommendations for application. No brand other than those named will be considered for approval unless the brand and type of paint proposed for each item in the following schedule together with sufficient data substantiated by certified tests conducted at no cost to the Owner, to demonstrate its equality to the paint(s) named is submitted to the Engineer in writing for approval within 30 days after the Effective Date of the General Contract. The type and number of tests performed shall be subject to the Engineer's approval.

B. All painting materials shall be delivered in unbroken packages, bearing the manufacturer's brand and name. They shall be used without adulteration and mixed, thinned and applied in strict accordance with manufacturer's directions for the applicable materials and surface and with the Engineer's approval before using.

C. Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with the finish paints to be used. Refer to Section 09901 for special primers.

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D. No paint containing lead will be allowed. Oil shall be pure boiled linseed oil.

E. Work areas will be designated by the Engineer for storage and mixing of all painting materials. Materials shall be in full compliance with the requirements of pertinent codes and fire regulations. Proper containers outside of the buildings shall be provided and used for painting wastes and no plumbing fixture shall be used for this purpose.

F. VOC Content: Products shall comply with VOC limits of authorities having jurisdiction and, for interior coatings applied at project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Flat Paints and Coatings: 50 g/L.

2. Nonflat Paints and Coatings: 150 g/L.

3. Primers, Sealers, and Undercoaters: 200 g/L.

4. Anti-Corrosive and Anti-Rust Paints Applied to Ferrous Metals: 250 g/L.

5. Zinc-Rich Industrial Maintenance Primers: 340 g/L.

6. Pre-Treatment Wash Primers: 420 g/L.

7. Floor Coatings: 100 g/L.

8. Shellacs, Clear: 730 g/L.

9. Shellacs, Pigmented: 550 g/L.

G. Low-Emitting Materials: Interior coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

H. Colors: As selected by Engineer from manufacturer's full range.

2.02 COLOR CODING FOR PIPES AND EQUIPMENT

A. The color code establishes, defines and assigns a definite color for each process system. All elements which are an integral part of the system, that is originating from the equipment and/or supplying the equipment, shall be painted between and up to but not including the fixed flanges or the flexible conduit connections on the equipment. Valves and fittings shall be painted in the color of the main body of the pipe.

B. All pipes and equipment shall be painted according to Color Schedule attached. Elements which are not listed on the Schedule will be assigned a color by the Engineer and shall be treated as an integral part of the Contract.

C. All hanger saddles and pipe support floor stands shall be painted the same color and with the same paint as the pipe it supports. Hanger rods and hanger rod connections to building structure shall be painted to match the color of the wall or ceiling to which it is attached.

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2.03 LETTERING OF TITLES

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. Titles 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, flow check, strainer cleanout and all pieces of equipment.

B. Titles shall identify the contents by complete name at least once in each space through which it passes and thereafter by generally recognized abbreviations, letters or numerals as approved. Identification title 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. Title 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.

2.04 TITLES FOR EQUIPMENT

A. Titles indicated in attached schedules shall be provided in vinyl film as specified above on all equipment using 1-in high Optima Bold upper case, Grid 2 spacing, white or black in color as approved depending on substrate. Titles shall be mounted at eye level on machines where possible or at the upper most broad vertical surface of low equipment. Where more than one piece of the equipment item to be titled exists, the items shall be numbered consecutively as indicated on the mechanical drawings or as directed by the Engineer; for example Pump No. 1, Pump No. 2, etc. Titles shall be composed in more than one line if required and justified on the left hand side as approved.

2.05 EXTRA PAINT

A. Furnish one unopened gallon can of each type and each color of paint used.

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2.06 TESTING EQUIPMENT

A. Furnish to the Engineer for use on the Project for paint inspection, wet and dry film thickness gauges and all other equipment required by the Engineer for inspection.

PART 3 EXECUTION

3.01 PREPARATION OF SURFACES

A. All surfaces to be painted shall be prepared as specified herein and shall be dry and clean before painting. Special care shall be given to thoroughly clean interior concrete and CMU surfaces to receive polyamide cured epoxy paint of all marks before application of finish.

B. All metal welds, blisters, etc., shall be ground and sanded smooth. All pits and dents shall be filled and all imperfections shall be corrected so as to provide a smooth surface for painting. All rust, loose scale, oil, tar and asphalt bearing coatings, grease and dirt shall be removed by use of approved solvents, wire brushing, grinding or sanding.

C. Concrete surfaces shall have been finished as specified in Section 03350. Report unsatisfactory surfaces to the Engineer. Concrete shall be left for one month minimum before painting and shall be free of dust, oil, curing compounds and other foreign matter.

D. Concrete masonry unit surfaces shall be smooth and cleaned of all dust, loose mortar and other foreign matter.

E. Submerged concrete surfaces and those subject to splashing, scheduled to be painted and for tank coating system and chemical fill station containment, shall be brush sandblasted to open void spaces and bug holes in accordance with SSPC SP #13 and ICRI Guideline No. 03732. Prepared surfaces shall exhibit a uniform ICRI Concrete Surface Profile (CSP) between CSP #3 and #5.

F. All PVC pipe and other plastic matrix surfaces to be painted shall be lightly sanded and cleaned of residue before painting.

G. Wood surfaces shall be dry. All encrustations shall be removed. Sand to obtain a smooth surface.

H. Galvanized (except metal deck surfaces), aluminum, and copper surfaces shall have all oxidation and foreign material removed before painting by SSPC SP-1, using an approved V.O.C. compliant method. Galvanized shall be prepared in accordance with ATSM D 6386, latest revision and prepared in accordance with SSPC SP-7 Standard, or equivalent power tool (SSPC SP-11) Standard to provide a uniform 1 to 2 mil angular surface profile.

I. Galvanized steel roof deck shall have oxidation, oils and foreign materials removed and surfaces given a uniform profile without compromising the galvanized coatings. Use SSPC SP-1 and SSPC SP-7 methods as submitted and approved.

J. Stainless steel shall be solvent cleaned as specified above and then sanded to achieve a uniform 1 mil profile. Remove all sanding residue.

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3.02 PAINTING SCHEDULE

A. All colors will be selected by the Engineer based on the Color Schedule herein.

B. The following types of paints by Tnemec Co. have been used as a basis for the paint schedule:

1. Hi-build Epoxoline II (Series L69) polyamidoamine epoxy

2. Envirofil (No. 130-6601 olive color) - waterborne cementitious acrylic

3. Endura-Shield - semi-gloss (Series 750) - high -build polyester polyurethane.

4. Hydro-Zinc (Series 94 –H20) - organic vehicle zinc-rich (NSF Standard 61 certified).

5. Tnemec-Glaze (Series 282) - 100% solids Novolac Epoxy.

6. Enduratone (Series 1029) - acrylic emulsion, semi-gloss finish.

7. Mortar-Clad (Series 218 and 217) - water-based modified epoxy cement

8. Potapox 100 (Series FC22) modified low-temp cure 100% solids polyamine cured epoxy (NSF Standard 61 certified for contact with potable water)

9. ChemTread (Series 239SC) - 100% solids modified novolac polyamine epoxy.

10. PPG Industries Rez Polyurethane Satin Clear Plastic Interior Varnish 77-89 - Urethane - alkyd, clear, satin sheen with approved Rez alkyd-oil stain under.

C. The following surfaces shall have the types of paint scheduled below applied at the dry film thickness (DFT) in mils per coat noted:

1. Finish painting of concrete in tanks.
   a. 1 coat Series FC 22 (30-40 mils DFT)

2. Exterior non submerged ferrous metals.
   a. 1 coat Series 94H20 Hydro-Zinc on properly prepared unprimed metal or for touch up (2.0 – 3.0 DFT)
   b. 1 coat Series L69 (4.0 DFT), 1 coat Series 750 (3.0 DFT)

3. Interior non-submerged concrete scheduled for painting.
   a. 2 coats Series L69 (5.0 DFT)

4. Interior concrete masonry units
   a. 1 coat No. 130-6601 (80 sq. ft./gal minimum scrub-in to fill voids as approved)
   b. 2 coats Series L69 (5.0 DFT)

5. Interior non-submerged ferrous metals
   a. 1 coat Series 94-H20 Hydro-Zinc on properly prepared unprimed metal or for touch-up (2.0 – 3.0 DFT)
   b. 2 coats Series L69 (3.0 DFT)

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6. Submerged ferrous metals and ferrous metals subject to submersion or splashing. Surface shall be lightly sanded or abraded before application of first field coat.
   a. 2 coats Series FC 22 (6.0 DFT)

7. Plastic piping and, where scheduled to be painted, plastic components
   a. 2 coats Series L69 (3.0 DFT)

8. Galvanized steel roof deck
   a. 2 coats Series L69 (3.0 DFT)

9. Other galvanized deck requiring painting and galvanized metals (Prep Deck in accordance with ASTM D 6386 prior to painting)
   a. Interior: 2 coats Series L69 (3.0 DFT)
   b. Exterior: 1 coat Series L69 (4.0 DFT), 1 coat Series 750 (3.0 DFT)

10. Pipe insulation
    a. 2 coats Series L69 (3.0 DFT)
    b. (Plastic or metal sheathed insulation-paint as scheduled for appropriate substrate)

11. Aluminum designated to be painted.
    a. Interior: 2 coats Series L69 (3.0DFT)
    b. Exterior: 1 coat Series L69 (4.0 DFT), 1coat Series 750 (3.0 DFT)

12. Copper piping
    a. 2 coats Series L69 (3.0 DFT)

3.03 WORKMANSHIP

A. General

1. At the request of the Engineer, sample areas of the finished work prepared in strict accordance with this Section shall be furnished and all painting shall be equal in quality to the approved sample areas. Finished areas shall be adequate for the purpose of determining the quality of workmanship. Experimentation with factory or paint manufacturer's warehouse mixed colors shall be furnished to the satisfaction of the Engineer where standard chart colors are not satisfactory.

2. Protection of furniture and other movable objects, equipment, fittings and accessories shall be provided throughout the painting operation. Canopies of lighting fixtures shall be loosened and removed from contact with surface, covered and protected and reset upon completion. Remove all electric plates, surface hardware, etc., before painting, protect and replace when completed. Mask all machinery nameplates and all machined parts not receiving a paint finish. Dripped or spattered paint shall be promptly removed. Lay drop cloths in all areas where painting is being done to adequately protect flooring and other work from all damage during the operation and until the finished job is accepted.

3. On metal surfaces apply each coat of paint at the rate specified by the manufacturer to achieve the minimum dry mil thickness required. If material has thickened or must be diluted for application by spray gun, the coating shall be built up to the same film thickness achieved with undiluted material. One gallon of paint as originally furnished by the manufacturer shall not cover a greater area when applied by spray gun than when applied,

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un-thinned, by brush. Deficiencies in film thickness shall be corrected by the application of an additional coat(s). On masonry, application rates will vary according to surface texture; however, in no case shall the manufacturer's stated coverage rate be exceeded. On porous surfaces, it shall be the painter's responsibility to achieve a protective and decorative finish either by decreasing the coverage rate or by applying additional coats of paint.

B. Field Priming

1. Steel members, metal castings, mechanical and electrical equipment and other metals which are shop primed before delivery at the site will not require a prime coat on the job. All piping and other bare metals to be painted shall receive one coat of primer before exposure to the weather, and this prime coat shall be the first coat as specified in the painting schedule. Surface preparation of bare metal shall be the responsibility of the Contractor.

2. Equipment which is specified to receive a baked-on enamel finish or other factory finish shall not be field painted unless the finish has been damaged in transit or during installation. Surfaces that have been shop painted and have been damaged or where the shop coat or coats of paint have deteriorated, shall be properly cleaned and retouched before any successive painting is done on them in the field. All such field painting shall match as nearly as possible the original finish. Preparation and painting shall be provided by the Contractor.

3. Equipment shipped with a protective shop painting coat or coats shall be touched up to the satisfaction of the Engineer with primers as recommended by the manufacturer of the finish paint. Preparation and painting shall be provided by the Contractor.

C. Field Painting

1. All painting at the site shall be under the strict inspection of the Engineer. Only skilled painters and, where dictated by special conditions or systems and so ordered, specialist painters shall be used on the work.

2. All paint shall be at room temperature before applying, and no painting shall be done when the temperature is below 60 degrees F, in dust-laden air, when rain or snow is falling, or until all traces of moisture have completely disappeared from the surface to be painted.

3. Successive coats of paint shall be different shades (from paint manufacturer's stock or shop mixed paint) of the required colors so as to make each coat easily distinguishable from each other with the final undercoat the approximate shade of the finished coat to ensure no show-through as approved.

4. Finish surfaces shall not show brush marks or other irregularities. Undercoats shall be thoroughly and uniformly sanded with the type paper appropriate for the undercoats to remove defects and provide a smooth even surface. Top and bottom edges of doors shall be painted.

5. Painting shall be continuous and shall be accomplished in an orderly manner so as to facilitate inspection. Materials subject to weather shall be primed coated as quickly as possible. Surfaces of exposed members that will be inaccessible after erection shall be cleaned and painted before erection.

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6. All painting shall be performed by approved methods with number of coats modified as required to obtain the total dry film thickness specified. Spray painting shall be performed specifically by methods submitted and as approved by the Engineer.

7. All surfaces to be painted as well as the atmosphere in which painting is to be done shall be kept warm and dry by heating and ventilation, if necessary, until each coat of paint has hardened. Any defective paint shall be scraped off and repainted in accordance with the Engineer's directions.

8. Before final acceptance of the work, all damaged surfaces of paint shall be cleaned and repainted as directed by the Engineer.

9. Only the aluminum work noted on the Drawings or in the Painting Schedule shall be field painted.

3.04 CLEANUP

A. At all times keep the premises free from accumulation of waste material and rubbish caused by employees or work. At the completion of the painting, remove all tools, scaffolding, surplus materials and all rubbish from and about the buildings and leave the work "broom clean" unless more exactly specified.

B. Upon completion, remove all paint where it has been spilled, splashed, or spattered on all surfaces, including floors, fixtures, equipment, furniture, etc., leaving the work ready for inspection.

END OF SECTION

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SECTION 11000
GENERAL REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: This section describes general requirements applicable to all process equipment unless otherwise required in the individual equipment sections.

1.02 QUALITY ASSURANCE

A. Reference Standards:

1. AGMA 9: Load Ratings and Fatigue Life for Ball Bearings.

2. ABMA 11: Load Ratings and Fatigue Life for Roller Bearings.

3. ANSI B1.1: Unified Inch Screw Threads (UN and UNR Thread Form).

4. ANSI B1.20.1: Pipe Threads, General Purpose (Inch).

5. ANSI B16.1: Gray Iron Pipe Flanges and Flanged fittings, (Classes 25, 125, and 250).

6. ANSI B18.2.1: Square and hex Bolts and Screws (Inch Series).

7. ANSI B18.2.2: Square and Hex Nuts (Inch Series).

8. ANSI S2.19: Mechanical Vibration – Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Unbalance, Including Marine Applications.

B. BALANCE:

1. Unless otherwise required, balance rotating elements for all machines 10 HP and greater to the following criteria:

$$U_{per} = 6.015 * \frac{GW}{N}$$

Where:

Uper	=	permissible imbalance, ounce-inches, maximum
G	=	Balance quality grade, millimeters per second
W	=	Weight of the balanced assembly, pounds mass
N	=	Maximum operational speed, rpm

2. All rotating elements in motors, pumps, blowers and centrifugal compressors shall be fully assembled, including couplings before being statically and dynamically balanced.

3. Where required, prepare report demonstrating compliance with balance quality grade of G 2.5 (G = 2.5 mm/sec) or better in accordance with ANSI S2.19.

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1.03 SUBMITTALS

A. Balancing reports for machines 10 HP and larger with rotating elements.

B. Consolidated lubricant list for mechanical equipment.

PART 2 PRODUCTS

2.01 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances shall conform in dimensions and drilling to ANSI B16.1, Class 125 unless the released-for-construction design documents require higher pressure ratings or connection to interfacing piping with raised face flanges. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise required, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.02 BEARINGS

A. Unless otherwise required, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service required. Each bearing shall be rated in accordance with the latest revisions of ABMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless otherwise required, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or shall be provided with appropriate shielding that will prevent inadvertent human contact.

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2.03 V-BELT ASSEMBLIES

A. Unless otherwise required, V-belt assemblies shall be Dodge Dyna-V belts with matching Dyna-V sheaves and Dodge Taper-lock bushings, or Wood's Ultra V-belts with matching Ultra-V sheaves and Wood's Sure-Grip bushings.

B. Sheaves and bushings shall be statically balanced. Additionally, sheaves and bushings which operate at a peripheral speed of more than 5500 feet per minute shall be dynamically balanced. Sheaves shall be separately mounted on their bushings by means of three pull-up grub or cap tightening screws. Bushings shall be key seated to the drive shaft.

C. Belts shall be selected for not less than 150 percent of rated driver horsepower and, where two sheaves sizes are required, shall be capable of operating with either set of sheaves. Belts shall be of the antistatic type where explosion proof equipment is required.

2.04 PUMP SHAFT SEALS

A. General: Unless stated otherwise, provide mechanical seals for water and wastewater pump shafts. Provide stuffing box with packing only where explicitly required.

B. Mechanical Seals:

1. Unless otherwise required, provide self-aligning, self-centering, single, split mechanical seals requiring no field assembly, other than assembly around the shaft and insertion into the pump. They shall be of a nondestructive (nonfretting) type requiring no wearing sleeve for the shaft. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through the seal area (no shaft sleeve). Where the detailed specifications call for cartridge instead of split seals, all other requirements of this paragraph apply.

2. Metal parts shall be Type 316 or 316L stainless steel. Springs shall be Hastelloy C, Elgiloy, or other Duplex SS selected for resistance to chloride attack. Rotary faces shall be silicon carbide or chrome oxide. Stationary faces shall be silicon carbide for solids bearing fluid service and carbon for clean water service. Elastomers shall be ethylene propylene or fluorocarbon. Mechanical seals shall be suitable for operation between full vacuum (0 psia) up to 200 percent of the maximum specified operating pressure, but in any event not less than 200 psig.

3. Seal chambers shall be provided with vented solids removal restriction bushings except for enclosed line shaft pumps where the seal barrier fluid is used for line shaft bearing lubrication. The bushing shall both control the amount of flushing water flow and restrict solids and gas accumulation from the seal face area.

4. Candidate seals include:
    1. Chesterton 442 seals provided with Chesterton/SpiralTrac solids removal restriction bushings Version N or D, as recommended by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.
    2. AESSEAL RDS seals with Cyclops bushing.
    3. John Crane 3710 seals with Type 24SL bushing.

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5. Seals on pumps for contaminated water service (sludge, grit, wastewater, scum, reclaimed water, etc.) shall be drilled and tapped for connection of a clean water flushing supply.

6. Seals for all vertical pumps (whether column or volute type) shall be provided with a second flush connection. Vertical pumps shall have a vent valve attached to the mechanical seal to eliminate air from the seal chamber prior to pump start; start-up procedures shall include venting instructions; and for remotely started pumps, the vent system shall be automated. Provide permissive confirmation automatic vent systems where required.

C. Shaft Packing:

1. Where shaft packing is required, stuffing boxes shall be tapped to permit introduction of seal liquid and shall hold a minimum of five rows of packing. Stuffing boxes shall be face attached. Stuffing box and shaft shall be suitable for field installation, without machining or other modifications, of the shaft seal.

2. Unless otherwise required, lantern rings shall be bronze or Teflon, packing shall be die-molded packing rings of non-asbestos material suitable for the intended service and as recommended by the equipment manufacturer, and glands shall be bronze, two piece split construction. Lantern rings shall be of two-piece construction and shall be provided with tapped holes to facilitate removal. Lantern rings shall be drilled and tapped 1/4 NC-20. The impeller end of the packing on all but line shaft pumps with external source water lubricated bearings shall be fitted with a SpiralTrac, Version P packing protection system as manufactured by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.

3. The section of each shaft or impeller hub that extends through or into the stuffing box shall be fitted with a replaceable stainless steel sleeve with a Brinell hardness of not less than 500. The sleeve shall be held to the shaft to prevent rotation and shall be gasketed to prevent leakage between the shaft and the sleeve. Minimum shaft sleeve thickness shall be 3/8 inch.

4. Provide seal water system (6 – 10 gallons/hour plant service water) including a rotameter, throttle valve and solenoid operated isolation valve interlocked with an auxiliary contact of the motor starter.

2.05 COUPLINGS

A. Unless otherwise required, equipment with a driver greater than 1/2 HP, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taper lock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.

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B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, or Falk Steel Flex, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.06 BASEPLATES

A. Unless otherwise required, provide all pumps with the manufacturers' baseplates designed to be installed on a housekeeping curb and machined flat to be co-planar within 0.002 inch per foot in all directions on the face mating with the pump and motor or driver support.

2.07 CAUTION SIGNS

A. Identify equipment with guarded moving parts which operates automatically or by remote control by signs installed near the moving part and reading "CAUTION - AUTOMATIC EQUIPMENT MAY START AT ANY TIME." Fabricate signs using fiberglass material, minimum 1/8 inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size, pattern and installation location shall be as required.

2.08 GAGE TAPS, TEST PLUGS AND GAGES

A. Provide gage taps with pressure, vacuum, or compound gages as appropriate to the application on the suction and discharge sides of pumps, blowers and compressors.

2.09 LUBRICANTS

A. Provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the commissioning period to final acceptance of the equipment. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of a lubricant supplier acceptable to the Owner. Limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Prepare a list showing the required lubricants, after consolidation, for each item of mechanical equipment indicating estimated quantity of lubricant needed for a full year's continuous operation.

2.10 ANCHOR BOLTS

A. Design anchor bolts for lateral forces for both pullout and shear. Unless otherwise required, anchor bolt materials shall conform to the following:

1. Anchor bolt holes in equipment support frames shall not exceed the bolt diameters by more than 25 percent, up to a limiting maximum oversizing of 1/4 inch. Unless otherwise required, minimum anchor bolt diameter shall be 1/2 inch Tapered washers shall be provided where mating surface is not square with the nut.

2. Expansion, wedge, or adhesive anchors set in holes drilled in the concrete after the concrete is placed will not be permitted in substitution for anchor bolts except where otherwise required. Upset threads shall not be acceptable.

3. Anchor bolt materials shall be as required in Table 11000-1.

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Table 11000-1, Anchor Bolt Materials

Material	Specification
Steel bolts	ASTM A307, Grade A
Fabricated steel bolts	ASTM A36
Stainless steel bolts, nuts, washers	ASTM A320, Type 316
Expansion anchors	HILTI-BOLT, or McCulloch Industries.
Wedge anchors	ITT, or Phillips Drill Co.
Adhesive anchors	HILTI-HVA, or PARABOND Capsule.

B. Fieldwork, including cutting and threading, shall not be permitted on galvanized items. Dissimilar metals shall be protected from galvanic corrosion by means of pressure tapes, coatings or isolators.

C. Anchor bolts to be embedded in concrete shall be placed accurately and held in correct position while the concrete is placed. Alternatively, recesses or blockouts may be formed in the concrete and the metalwork may be grouted in place if required in released-for- construction design documents. The surfaces of metalwork in contact with concrete shall be thoroughly cleaned. After anchor bolts have been embedded, their threads shall be protected by grease and the nuts run on.

D. Use of adhesive or capsule anchors shall be subject to Owner acceptance and the following conditions:

1. Use shall be limited to locations where exposure, on an intermittent or continuous basis, to acid concentrations higher than 10 percent, to chlorine gas, or to machine or diesel oils, is extremely unlikely.

2. Use shall be limited to applications where exposure to fire or exposure to concrete or rod temperature above 120 degrees F is extremely unlikely. Overhead applications (such as pipe supports) because of the above concerns, shall be disallowed.

3. Approval for the specific application from the equipment supplier.

4. Anchor diameter and grade of steel shall conform to released-for-construction design documents and equipment supplier specifications. Anchor shall be threaded or deformed full length of embedment and shall be free of rust, scale, grease, and oils.

5. Embedment depth shall conform to released-for-construction design documents and equipment supplier specifications. Adhesive capsules of different diameters may be used to obtain proper volume for the embedment, but no more than two capsules per anchor may be used. When installing different diameter capsules in the same hole, the larger diameter capsule shall be installed first. Any extension or protrusion of the capsule from the hole is prohibited.

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6. All installation recommendations by the anchor system manufacturer shall be followed carefully, including maximum hole diameter.

7. Holes shall have rough surfaces, such as can be achieved using a rotary percussion drill.

8. Holes shall be blown clean with compressed air and be free of dust or standing water prior to installation.

9. Anchor shall be left undisturbed and unloaded for full adhesive curing period.

10. Concrete temperature (not air temperature) shall be compatible with curing requirements of adhesives per adhesive manufacturer. Anchors shall not be placed in concrete below 25 degrees F.

2.11 SPARE PARTS

A. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment and accessories in accordance with manufacturer recommendations unless otherwise required in an individual equipment specification section.

END OF SECTION

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SECTION 11002
EQUIPMENT SUPPORTS, GROUTING AND INSTALLATION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This section specifies minimum requirements for equipment supports, including concrete housekeeping pads, equipment bases, supports, anchorage, and accessories with weights greater than 200 pounds. If conflict exists between this section and requirements of individual equipment manufacturers, the more restrictive requirements shall prevail.

B. Mounting Requirements: The Contractor shall provide all supports, anchorage, and mounting of all equipment, unless otherwise specified in accordance with the manufacturer's recommendations and industry standards requirements. Each piece of equipment shall be anchored to resist the greater of the maximum lateral and vertical forces required by the local governing code or by the manufacturer of the equipment, whichever is greater. This force shall be considered acting at the center of gravity of the piece under consideration. No equipment shall be anchored to vertical structural elements without written approval of the Engineer. The Contractor shall provide all elements required to resist the calculated forces described herein or required by the equipment manufacturer. The Contractor shall provide certification that for equipment, 20 horsepower and larger, anchor bolt calculations showing adequacy of bolt sizing and anchor embedment have been performed and signed by a structural or civil engineer registered in the State of Tennessee.

1.02 SUBMITTALS

A. The following information shall be provided, in accordance with Section 01300 and for approval by the Engineer:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
    1. Check marks shall denote full compliance with a paragraph as a whole.
    2. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
    3. Shop drawings for all equipment bases and anchorage details.

2. Certification of anchor bolt calculations specified in Paragraph 1.01 B.

3. Machine and equipment base installation schedule with manufacturers' anchor bolt torque requirements, as specified in Paragraph 2.01.

4. Results of grout strength tests, as specified in Paragraph 3.02 E.

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1.03 REFERENCES

A. This section contains references to the following documents. The documents are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed document, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the date of bid opening. 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, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/HI 1.3.4	Centrifugal Pumps, Horizontal Baseplate Design
ANSI/HI 1.4	Centrifugal Pumps – Installation, Operation and Maintenance
ANSI/HI 2.4	Vertical Pumps – Installation, Operation and Maintenance
API 610, 1995	Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services
API RECOMMENDED PRACTICE 686	Recommended Practices for Machinery Installation and Installation Design
ASTM C531	Linear Shrinkage and Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts, and Monolithic Surfacings.
ASTM C579	Compressive Strength of (Method/B) Chemical Resistant Mortars and Monolithic Surfacings.
ASTM C638	Tensile Properties of Plastics.
ASTM C882	Bond Strength of Epoxy-Resin Systems Used with Concrete
ASTM C884	Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay
ASTM C1181	Creep of Concrete in Compression
ASTM D2471	Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins
SSPC	Society for Protective Coatings Specifications, Vol. 2

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise specified, equipment and drivers shall be rigidly mounted on a common cast iron or fabricated steel baseplate or soleplate grouted into place on concrete housekeeping pads. All equipment shall be mounted on concrete housekeeping pads. Under no circumstances shall

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equipment supports be grouted directly to concrete slabs or floors. Bases for equipment shall be hot-dip galvanized after fabrication unless otherwise specified. Mounting pads for equipment shall have the zinc layer removed and shall be finished flat and parallel after galvanizing. Sole plates and leveling plates shall not be galvanized. Machined surfaces shall be protected with two layers of duct tape after machining and before shipment from the factory.

B. Prior to initiating any installation efforts, the Contractor shall produce a machine base schedule containing the expected dates for setting anchor bolts, casting housekeeping pads, preparation of housekeeping pads for grouting, grouting, and final anchor bolt clamping for each item of equipment. The schedule shall list the equipment, by equipment number, and shall be accompanied by written verification of anchor bolt clamping torque from the equipment manufacturer.

C. Installation practices shall follow the guidance presented in Chapters 4 and 5 of API Recommended Practice 686, unless superseded by more restrictive requirements of these specifications or manufacturer requirements.

2.02 CONCRETE HOUSEKEEPING PADS

A. Concrete housekeeping pads for equipment and floor penetrations shall be at least 2 inches larger in plan than the steel or cast base and not less than 6 inches above the finished floor elevation, and shall be shaped to drain liquids away from the base. Housekeeping pad details shall follow the requirements set forth on Figure A-4 of API 686 unless superseded by more restrictive requirements of these specifications or the requirements of the equipment manufacturer. All conduits, piping connections, drains, etc., serving the equipment, shall be enclosed by the concrete pad. Unless otherwise specified, no conduits, piping connections, drains, etc., will be accepted which rise directly from the floor.

2.03 EQUIPMENT BASES

A. General:

1. Unless otherwise specified, mounting bases for equipment 20 horsepower and larger shall be a minimum of 1 inch thick. All bases shall have edges bearing on the grout surface rounded to a radius of not less than 2 inches to avoid producing stress risers on the grouted foundation. Grout pouring holes shall be provided in all bases and all bases shall have grout release holes. Except where vibration isolation systems are specified, all bases shall be grouted as specified in this section. Internal stiffeners shall be provided and shall be designed to allow free flow of grout from one section of the base to another. The minimum acceptable opening in cross-bracing and stiffeners shall be 2 inches high by 6 inches in length. All welds shall be continuous and free from skips, blowholes, laps and pockets.

2. Equipment bases for horizontal pumps shall conform to the requirements of this section, ANSI/HI 1.3.4, API 610 (paragraph 3.3), and shall provide common support for the pump and motor. In the event of conflict, the requirements of this section shall govern. Eight positioning jackscrews shall be provided for all drivers for all horizontal pump baseplates. All bases for horizontal pumps shall be equipped with jackscrews for positioning and leveling the base prior to grouting.

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3. Mounting holes for anchor bolts in the bases shall be drilled and not burned out and they shall not be open slots. All mounting studs shall be Type 316 stainless steel. Unless otherwise specified under individual equipment specifications, anchor bolts shall be Type 304 stainless steel or Type 316 SS for chemical areas. Anchor bolts shall be as sized as specified under paragraph 1.01 B or as per certification by equipment manufacturer. A nonseize or nongalling compound shall be used on all threads.

4. Mounting pads for equipment shall be machined after all welding and stress relieving and shall be coplanar to 0.002 inch in all directions. Mounting pads shall extend not less than 1 inch on all sides beyond the position for the equipment.

5. Equipment bases for vertical volute-type pumps weighing more than 2,000 pounds shall be soleplates or leveling boxes under individual feet or support brackets integral with the volute casting. Direct mounting of the volute on housekeeping pads will not be permitted.

6. Sole plates, mounting blocks and baseplates weighing more than 1,000 pounds shall be leveled with jackscrews incorporated into the fabrication. Jackscrews shall be located in thickened pads or otherwise in sufficient metal to provide ease in adjusting level.

B. Type I Bases:

1. Type I bases shall be structural steel bases with thickened steel pads for doweling. The bases shall be rectangular in shape for equipment other than centrifugal refrigeration machines and pump bases, which may be "T" or "L" shaped to accommodate the equipment drive and accessories. Pump bases for split case pumps shall include supports for suction and discharge base ells, if required by the specified configuration. Perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth need not exceed 14 inches provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Terminations requiring connections to the base shall be nuts welded to the bottom side of the base and plugged with cork, plastic plugs or grease, or acorn nuts. Grout holes shall be provided for the bases of all equipment where vibration isolation is not specified.

C. Type II/III Bases: Not Used

D. Type IV Bases: Type IV bases shall be cast iron. Cast iron bases located within buildings do not require galvanizing but shall be sealed in accordance with the requirements for bleeding surfaces specified in Section 09901 prior to grouting. Terminations requiring connections to the base shall be nuts welded to the bottom side of the base and plugged with cork, plastic plugs or grease, or acorn nuts. In no case shall the fastener terminate only into the metal base.

E. Soleplates: Where soleplates are provided, the underside shall be scribed with the words “THIS SIDE DOWN” using welding rod material prior to milling the equipment mating surface flat to a tolerance of not less than 0.002/foot in all directions.

2.04 GROUT FOR EQUIPMENT BASES

A. Epoxy Grout:

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1. Unless otherwise specified, grout for equipment bases shall be non-shrinking epoxy grout conforming to the following requirements:

Test	Result
ASTM C531	Shrinkage shall be less than 0.080% and thermal expansion less than 17 x 10^{-6} in/in/^{o}F
ASTM C579	Strength shall be a minimum of 12,000 psi in 7 days when tested by method B, modified.
ASTM C882	Bond strength to Portland concrete shall be greater than 2000 PSI
ASTM C884	Epoxy grout shall pass the thermal compatibility test when overlayed on Portland cement concrete
ASTM D638	Tensile strength shall not be less than 1700 psi. Modulus of elasticity shall not be less than 1.8 x 10^{6} psi
ASTM C1181	Creep of the epoxy grout shall be less than 0.005 in/in with the test at 70^{o}F and 140^{o}F with a load of 400 psi
ASTM D2471	Peak exothermic temperature shall not exceed 110^{o}F when a specimen 6-inch diameter x 12 inches high is used. Gel time shall be a least 150 minutes

2. The vehicle shall be a two-component (liquid and hardener) system designed to yield the above characteristics when combined with the manufacturer's recommended aggregate system. The grout shall be suitable for supporting precision machinery subject to high impact and shock loading in industrial environments while exposed to elevated temperature as high as 150 degrees F, with a load of 1200 psi. Aggregate for equipment base grout shall be as furnished by the manufacturer of the epoxy grout mix.

B. Cementitious Grout: Cementitious grout for use with equipment supports for equipment rated 5 horsepower and smaller or weighing less than 1000 pounds, whichever is less, may be as specified in Division 3. Procedures for leveling and clamping equipment shall be as specified in this section.

2.05 EPOXY PRIMER

A. The epoxy primer shall be a lead free, chrome free, rust inhibitive, two-component epoxy primer specifically designed for use on metal substrates and in conjunction with epoxy grout. The epoxy primer shall be a product of the epoxy grout manufacturer.

2.06 ANCHOR BOLTS

A. Unless otherwise indicated in the equipment specifications or as indicated by equipment manufacturer, anchor bolts shall be Type 304 stainless steel or Type 316 SS for chemical areas. Anchor bolts shall be set in PVC sleeves. Sleeves shall allow a free length projection of not less than fifteen bolt diameters above the concrete required to develop the strength of the bolt. Projection of the bolt above the nut on the baseplate or soleplate shall be no more than 3/4 inch.

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Anchor bolts shall be located not less than 6 anchor bolt diameters from the foundation edge in all directions.

PART 3 EXECUTION

3.01 GENERAL

A. Pumps shall be installed in accordance with this section and ANSI/HI 1.4 and ANSI/HI 2.4. Grouting of equipment bases shall take place prior to connecting any field piping or electrical and instrumentation systems. Unless the Engineer accepts an alternate installation procedure in writing, baseplates shall be grouted with the equipment removed.

B. Equipment that is not mounted on vibration isolators shall be anchored directly to the supporting floor system. In addition to the anchorage, all such equipment shall be internally designed so that all static and moving parts are anchored to the supporting framework to resist the all imposed forces. All forces shall be transmitted to the base in order to be anchored as required.

C. Connecting piping with flexible connections and/or expansion joints shall be anchored such that the intended uses of these joints are maintained in the piping system without imposing strain on the equipment connections. Where the equipment manufacturer requires a rigid connection between the machine and connecting piping systems (generally, this will be higher discharge head pumps), the flexible coupling shown may be deleted and the Contractor shall install the equipment in the following manner:

1. The equipment housekeeping pad shall be prepared as specified under Paragraph 3.02 B.

2. The baseplate, soleplate or leveling blocks supporting the equipment shall be installed, leveled, and grouted in place as specified.

3. The equipment shall be installed, aligned and doweled in place as specified.

4. The piping shall be installed and aligned to the equipment connections and the field piping connections with out welding one of the joints for one section of pipe between the equipment connection and the field piping and all valving. All flanged joints shall be bolted up and pressure tested.

5. All piping shall be fully supported by supports designed to accept their full weight.

6. The final sections of pipe shall be aligned with the equipment and field connections without the use of jacks, chain falls or other devices to force it into alignment.

7. The final piping joints shall be welded only after the previous steps have been completed and accepted by the Engineer.

D. Conduit and piping for future equipment shall be capped flush with the floor or concrete pad in such a manner to allow future connection.

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E. The Contractor shall coordinate location of electrical conduit and piping penetrations within the concrete pad and equipment base. All penetrations shall stub-up on the same side of the equipment as required for connection to the equipment. Equipment drains shall be located as required for drainage from equipment.

F. Prior to commencing equipment installation work, the Contractor shall cause the manufacturer of the epoxy grout to be used for equipment installation to conduct a training school for the workmen to be using the product. The school shall be not less than 4 hours in length and shall cover all aspects of using the products from mixing to application. This requirement, however, shall not be construed as relieving the Contractor of overall responsibility for this portion of the work.

3.02 INSTALLATION

A. Anchor Bolts:

1. Prior to concrete placement, anchor bolts shall be accurately set according to the manufacturer's foundation drawings and firmly secured to prevent shifting during concrete placement. Drilled in anchor bolts will not be accepted. The bolts shall be embedded in the structural concrete to develop the full strength of the bolt. Concrete in housekeeping pads cannot be used for this purpose. All anchor bolts shall be dimensionally checked against the foundation drawings for proper length, diameter, thread length, thread projection, etc., by a representative of the equipment manufacturer prior to placing concrete. Prior to placing concrete for the housekeeping pad, plastic sleeves shall be placed around each bolt to provide for minor adjustment of bolt position prior to grouting. Sleeves shall be filled with a pliable, nonbonding material such as silicon rubber or wax to prevent contact between the concrete or grout and the anchor bolt. Bolt threads and projections in the sleeves (refer to paragraph 2.06) above the structural slab shall be protected in the sleeve by heavily greasing or waxing the threads and shank with paste wax and wrapping with plastic sheeting. The protective wrapping shall be firmly secured with tie wires. The protective wrapping shall be removed prior to placing the grout.

2. The equipment manufacturer shall recommend the size of the anchor bolts for the equipment and shall also furnish the recommended tightening torque for the nuts; however, the minimum size bolt shall be 3/4 inch for equipment rated 20 to 100 horsepower, 1 inch for equipment rated over 100 to 300 horse-power and 1-1/4 inches for 300 to 500 horsepower. Anchor bolts for equipment rated over 500 horsepower shall be as recommended by the manufacturer of the equipment and as approved by the Engineer.

B. Concrete Housekeeping Pad Preparation:

1. After the concrete is fully cured (sample cylinders, as specified in Division 3, shall be taken and tested for all housekeeping pads supporting equipment weighing more than 1000 pounds), the housekeeping pad shall be chipped approximately 3/4 inch to 1 inch to remove all laitance and defective or weak concrete. A light duty, hand held pneumatic chipper with a chisel type tool shall be used for chipping the foundation. Abrasive blast, bush-hammer, jackhammers with sharp chisels or needle gun preparation of concrete surfaces to be grouted are not acceptable. The amount of concrete removed shall be such that the final baseplate or soleplate elevation results in not less than 3 inches of grout

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between the surface of the housekeeping pad and lower baseplate flange or the underside of the soleplate.

2. All edges shall be chamfered 2 to 4 inches at a 45-degree angle. All dust, dirt, chips, oil, water, and any other contaminants shall be removed and cover the foundation shall be covered with protective plastic sheeting. The grout contact surface on the housekeeping pad shall be coated with one coat (not more than 5 mils) of catalyzed epoxy resin.

C. Equipment Bases And Soleplates: All surfaces of equipment bases and soleplates to be in contact with epoxy grout shall be cleaned to SP-6 and shall be primed with epoxy primer within 8 hours of cleaning.

D. Leveling And Shimming:

1. All machinery shall be mounted and leveled by millwrights. All equipment bases and equipment shall be leveled against steel surfaces. Use of other materials for leveling purposes is strictly and specifically prohibited. Unless otherwise specified, baseplates, mounting blocks and soleplates weighing less than 1000 pounds shall be leveled on stainless steel blocks 4 inches square and 1-1/2 inches thick with a hole drilled in the center for the anchor bolt, placed under the base at every anchor bolt. Leveling shall be by use of mounting blocks machined flat on all horizontal surfaces and measuring not less than 4 inches wide horizontally and shims that shall extend not less than three inches beyond the base of the equipment. Mounting blocks shall be coated with a light oil just prior to beginning the leveling and grouting work. Using precut stainless steel shims coated with a light oil between the base and the steel blocks at the anchor bolts, the Contractor shall level the equipment baseplates, soleplates or mounting blocks against the anchor bolt nuts (finger tight only) to a maximum tolerance of 0.0005 in./ft or as otherwise required by the equipment manufacturer, if more stringent. Mounting surfaces for equipment shall be coplanar within 0.002 inch in any direction. The shims shall be placed so the tabs on the shims are easily accessible. A minimum of four shims per anchor bolt shall be used. The total shim thickness at each anchor bolt shall be at least 0.015 inch. Leveling shall be against anchor bolts prior to final grouting.

2. The Contractor shall level the equipment against the anchor bolt nuts to a maximum tolerance of 0.002 in./ft or as otherwise required by the equipment manufacturer, if more stringent. Leveling equipment shall be precision surveying equipment. Machinists' spirit levels will not be permitted for leveling purposes for any base plate or equipment foundation with a plan dimension greater than 4 feet.

3. Leveling nuts may be used for mounting equipment weighing less than 500 pounds. The Contractor shall level the equipment against the anchor bolt nuts to a maximum tolerance of 0.0005 in./ft or as otherwise required by the equipment manufacturer, if more stringent. Anchor bolt nuts shall be only finger tight during the leveling process. Wedges will not be allowed and under no circumstances shall shims be used as permanent support under baseplates, soleplates or leveling plates.

E. Grouting:

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1. Grout forms shall be built of minimum of 3/4-inch thick waterproof plywood and shall be securely braced (minimum brace size shall be 2 inches x 4 inches). Forms shall provide a minimum of 2-inch hydrostatic head above the final elevation of the grout to assist in flow during installation.

2. Forms must be coated with three coats of paste wax on all areas that will come in contact with the grout to prevent the grout from bonding to the forms. Forms shall be waxed before assembly to prevent accidental application of wax to surfaces where the grout is to bond. Before any forms are installed, all concrete surfaces that will contact epoxy grout shall be free from any foreign material, such as oil, sand, water, grease, etc. Forms shall be liquid-tight. Any open spaces or cracks in forms, or at the joint between forms and the foundation, shall be sealed off, using sealant. All outside vertical and horizontal edges of the grout shall have 45-degree chamfers. Blockouts shall be provided at all shimming and leveling nut positions to allow removal of shimming equipment after the grout has cured. Jackscrews shall be coated with a light oil or other acceptable bond-breaking compound.

3. The 45-degree chamfer strip shall be located at the final elevation of the grout. The final elevation of the grout on baseplates with exposed I-beam or C-channel supports shall be at the top of the lower support flange. The top of the grout, on baseplates with solid sides and soleplates, shall be 1.0 inch above the bottom of the baseplate or the underside of the soleplate. The grout's final elevation shall not be so high as to bond the anchor bolt nut and washer.

4. The epoxy resin and hardener shall be mixed in accordance with the grout manufacturer’s recommendations. Aggregate shall be slowly added to the mixer one bag at a time. The grout should be mixed only long enough to wet out all the aggregate. Grout shall be placed at the center of one end of the baseplate or soleplate and worked toward the ends in such a manner as to force the air out from beneath the baseplate or soleplate and out the vent holes, to eliminate voids. The grout shall be placed in a manner that avoids air entrapment using a head box to pour grout into the grout holes. When the head box is moved to the next grout hole, a 6-inch high standpipe shall be placed over the grout hole and filled with grout. The Contractor shall exercise care to never allow the grout to fall below the baseplate level once the grout has made contact with the baseplate. Grout placement shall be continuous until all portions of the space beneath the baseplate or soleplate have been filled. Subsequent batches of grout shall be prepared so as to be ready when the preceding batch has been placed. Under no circumstances shall the grouting operation be halted because of lack of grout mix. After the entire baseplate is full, 6-inch high standpipes shall be maintained over each grout hole, to continue purging of air. When the grout has started to take an initial set (determined by a noticeable increase in temperature and no flow of grout at the vent holes) the standpipes shall be removed and excess grout cleaned from all surfaces.

5. A grout sample shall be taken for each piece of equipment to be grouted. The sample shall be placed in a cylinder of sufficient size to yield three 2-inch x 2-inch x 2-inch test samples. The samples shall be tagged with the equipment number and ambient temperature at the time of placement. The samples shall be tested in accordance with the manufacturer's recommendations. Once the epoxy grout cylinder has been completely filled, it shall be placed next to the foundation of the equipment being grouted and allowed to cure for 48 hours. After 48 hours, the test cylinder shall be tested in accordance with the grout

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manufacturer's recommendations by an independent testing laboratory. The results shall be reported directly to the Engineer. Forms shall be removed only after the grout has cured sufficiently and upon specific permission from the Engineer.

F. Completion:

1. Upon acceptance by the Engineer and the equipment manufacturer's representative after the grout has reached sufficient strength, the shims shall be removed, and leveling nuts or jack screws backed off to allow the grout to fully support the equipment base, leveling block or soleplate. Removal of extended shimming material (direct mounted baseplates weighing 1000 pounds or less) shall be by sledge hammer, taking care not to damage the grout. Once shims have been removed, or jackscrews backed off, the anchor bolts shall be torqued, using calibrated indicating torque wrenches, to develop the full clamping force required by the equipment manufacturer. Anchor bolts shall be torqued in increments of not more than 25 percent of final value in an alternating pattern to avoid stress concentration on the grout surface. Pockets for access to shims, or leveling nuts shall be filled with grout mix and pointed after the anchor bolts have been torqued to final values.

END OF SECTION

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SECTION 11050
GENERAL REQUIREMENTS FOR CENTRIFUGAL AND AXIAL FLOW PUMPING EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section provides minimum requirements applicable to centrifugal and axial flow pumping equipment furnished under this contract. More restrictive requirements, where found in individual pump specifications, shall supersede requirements of this section.

2. “Detailed pump specification,” “detailed specification,” “individual pump specification,” “referencing section,” or words of similar import in the following paragraphs, shall mean the specification section where the requirements for specific pump performance are presented.“Pumping unit,” whenever and wherever used, shall mean the complete pumping assembly, including driver (whether engine, turbine, or motor) and shall include all accessories such as variable speed drives required for motor operation, gear reducers, intermediate shafting and bearings, flywheels, and all supports for all equipment furnished with the pump.

B. Definitions - The following definitions apply for classifying pumps specified in this and referencing sections:

1. Solids Bearing Liquid: Liquids to be pumped containing, or assumed to contain, solids that require appropriate pump design considerations and/or materials of construction. Solids Bearing Liquids are liquids with settleable solids exceeding 50 mg/l and shall include wastewater, stormwater, primary effluent, return sludge, return activated sludge (RAS), trickling filter circulation, and similar services.

2. Clear Liquids: Liquids to be pumped generally free of deleterious solids.Clear Liquids shall include, potable water, heat reservoir, raw water, secondary effluent pumping, and similar services.

3. Efficiency: For the purposes of this section and sections referencing this section, efficiency, as related to pumps, shall be the ratio of the pump output power (water horsepower) divided by the pump input power (brake horsepower) required to deliver the total head, with meanings as defined in HI 1.2.6 and 2.2.6 and 2.2.3.8.For column type pumps, it shall be computed inclusive of inlet, bowl, column and discharge head losses.

4. Net Positive Suction Head – 3 Percent Reduction (NPSH3):For the purposes of this section and sections referencing this section, NPSH3 shall mean the value of net positive suction head resulting in a reduction of 3 percent in the developed pump discharge head when the pump is tested in accordance with procedures established by the Hydraulic Institute.NPSH3 is the successor designation to NPSHR (net positive suction head required).Where NPSHR is used in the Contract Documents it shall be taken to mean NPSH3.

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5. Size Threshold Criteria: A number of provisions of this section shall be required for a subset of pumps. These requirements are in addition to requirements applicable to all pumps. This subset of pumps is defined as pumping equipment meeting any of the following criteria:
    1. Pumps with motor sizes 250 Hp and greater.
    2. Pumps with discharge nozzles 20-inches in diameter and larger.
    3. Pumps with variable speed drives.
    4. Pumps operating at speeds 720 rpm and less.
    5. All flywheel-equipped pumps.
    6. All engine-driven pumps.
    7. All pumps driven by synchronous motors.
    8. Where a particular Section 11050 provision is specifically cited in the detailed section.

1.02 TYPE

A. Provisions and requirements contained in this section apply specifically to centrifugal and axial flow pumps, both vertical and horizontal, commonly falling into the generic types covered by ANSI/HI 1.1 through 1.6 and 2.1 through 2.6.This section does not apply, except by specific reference, to positive displacement pumps of any type.

1.03 REFERENCES

A. Reference Standards:

1. ABMA 9: Load Ratings and Fatigue Life for Ball Bearings.

2. ABMA 11: Load Ratings and Fatigue Life for Roller Bearings.

3. AISC: American Institute of Steel Construction – Steel Construction Manual, 13th Edition.

4. ANSI/HI 1.1 – 1.6: Centrifugal Pumps.

5. ANSI/HI 2.1 - 2.6: Vertical Pumps.

6. ANSI/HI 9.1 – 9.5: Pumps – General Guidelines.

7. ANSI/HI 9.6.1: Centrifugal and Vertical Pumps for NPSH Margin.

8. ANSI/HI 9.6.2: Centrifugal and Vertical Pumps for Allowable Nozzle Loads

9. ANSI/HI 9.6.3: Centrifugal and Vertical Pumps Allowable Operating Region.

10. ANSI/HI 9.6.4: Centrifugal and Vertical Pumps. Vibration Measurements

11. and Allowable Values

12. ANSI/HI 9.8: Pump Intake Design

13. ANSI/HI 11.6: Submersible Pump Tests.

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14. ANSI/API 610: Standard for Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries.

15. API 686/PIP REIE 686: Recommended Practices for Machinery Installation and Installation Design.

16. ASME B18.8.2: Taper Pins, Dowel Pins, Straight Pins, Grooved Pins, and Spring Pins (Inch Series).

17. ANSI/ASME B46.1: Surface Texture, Surface Roughness, Waviness and Lay.

18. ASME Code: ASME Boiler and Pressure Vessel Code.

19. ASTM A27: Steel Castings, Carbon, for General Application.

20. ASTM A36: Carbon Structural Steel

21. ASTM A148: Steel Castings, High Strength, for Structural Purposes

22. ASTM A322: Steel Bars, Alloy, Standard Grades

23. ASTM A564: Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes

24. ASTM A571: Austenitic Ductile Iron Castings for Pressure-Containing Parts Suitable for Low-Temperature Service

25. ASTM B148: Aluminum-Bronze Sand Castings

26. AWWA C213: Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

27. AWWA C550: Protective Epoxy Coatings for Valves and Hydrants

28. NSF/ANSI 61: Drinking Water System Components – Health Effects

29. ISO 9001: Quality Management Systems – Requirements, 3rd Ed. (2000)

30. ISO 10816-7: Mechanical Vibration—Evaluation of Machine Vibration by Measurement on Non-rotating Parts—Part 7: Rotordynamic Pumps for Industrial Applications, Including Measurements on Rotating Shafts, Annex A, Tables A-1 and A-2 as applicable.For the purposes of this specification, Annex A of ISO 10816, Part 7 shall form a part of this specification and ISO 10816, Part 7.

31. MIL STD 167-2: Mechanical Vibrations of Shipboard Equipment (Reciprocating Machinery and Propulsion System and Shafting)

32. Vibration Institute: Vibration Specialist Certification Requirements

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33. Corbo and Malanoski, 1996: Practical Design Against Torsional Vibration, 25th Turbomachinery Symposium, Turbomachinery Laboratory, Texas A & M University, p. 186 – 222

34. Corbo and Malanoski, 1998: Pump Rotordynamics Made Simple, Pumping Technology, June 1998, p. 202 – 236

1.04 DESIGN REQUIREMENTS – ALL PUMPS

A. General:

1. Equipment furnished under all sections referencing this section shall conform to the requirements and objectives of paragraph 5.1.1, ANSI/API 610.All components associated with the rotating elements in the drive train, including equipment supports and supports for rotating elements, shall be selected and designed to function without damage or disassembly at reverse rotational speeds up to 150 percent of maximum operational speed during flow reversals through the pump. The complete pumping unit shall operate without overload on any component at any point along the pump's entire full-speed operating curve. Pumps required by virtue of the specified operating conditions to operate against a closed valve or throttled for any period of time exceeding five seconds shall be furnished with drivers sized to operate continuously at the power requirement for that condition even though the power requirements at the rated condition may be less.

2. With the exception of submersible pumps and the inlet connection for pumps designed to operate in open forebays or wet wells, pump connection nozzles shall be designed for the loads and moments stipulated in ANSI/HI 9.6.2.Where ANSI/HI 9.6.2 does not cover a specific pump type or category, or where that document is silent on allowable nozzle loads or a particular type of nozzle load (e.g. thermal pipe strain), the Contractor shall furnish documentation from the manufacturer attesting to the limitations on loads and moment forces that can be tolerated on each connection and recommended connection details to be used.

B. Pump Selection:

1. Proven Designs: Pumps furnished under all sections referencing this section shall be proven designs that shall have been in service under similar conditions of volute or bowl, discharge case and nozzle size, impeller design (including number of vanes), pumped fluid, head, capacity, speed, rotation and Net Positive Suction Head Available (NPSHA) for a period of not less than five years. A detailed list, duly signed by an officer of the pump manufacturer and notarized, of installations with contact information supporting qualification under this requirement shall be submitted.
    1. Propose equipment that cannot meet this requirement only under the following conditions:
        1) The proposed design has been in successful operation under similar conditions of volute or bowl, discharge case and nozzle size, impeller design (including number of vanes), pumped fluid, head, capacity, rotation and NPSHA, but at a higher speed for a period of not less than three years; or
        2) The proposed design has been in operation in designs where both larger and smaller nozzle size pumps have been in service for a period of not less than five

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years, and impeller design (including number of vanes), pumped fluid, head, capacity, speed and NPSHA are similar to that for the proposed installation. Under no circumstances will an existing pump design operating at a higher speed than those currently in service in similar applications be considered.

2. If the proposed pump qualifies under either exception above, demonstrate, by operation of a test pump in a fully equipped hydraulic test facility, that the proposed pump in the size and at the speed proposed, with the proposed impeller design will have acceptable operating characteristics under the conditions specified for the proposed installation.

2. General Performance Criteria: Pumping equipment provided under any section referencing this section shall be suitable for the operating modes described in the detailed specification section and other relevant portions of this project manual. They shall be selected to place all specified continuous duty operating conditions within the manufacturer's Allowable Operating Region (AOR), as defined under ANSI/HI 9.6.3.Operating conditions are defined in the referencing sections.
   1. Pumps furnished under this section and any referencing section shall operate without damaging cavitation or vibration over the entire specified range of flow and head conditions and shall be specifically selected for NPSH margin requirements detailed herein. Pump selections which do not provide the specified margin will be rejected.
   2. Under no circumstances will centrifugal pumps with suction specific speeds in excess of 10,000 be considered unless specifically allowed in the detailed specification. Suction specific speed shall be calculated (using NPSH3) in accordance with ANSI/HI 1.3, paragraph 1.3.4.1.15.Each pump shall be subjected to a factory NPSH3 test at the pump's BEP to confirm that the suction specific speed limitation has not been exceeded.
   3. The pump selection for a given application shall be predicated on locating the specified most frequent operating condition in the proposed pump's Preferred Operating Region (POR), as defined in ANSI/HI 9.6.3.The Preferred Operating Region (POR) shall be not less than that specified in paragraph 5.1.14, ANSI/API 610.
   4. Proposed pump selections shall be selected to allow not less than a five percent increase in head, as specified in paragraph 5.1.6 of ANSI/API 610.Variable speed operation to achieve this objective will not be considered. Pump selections proposing maximum diameter impellers for the proposed pump model and casing size will not be allowed.

3. General Design Criteria: All pumps furnished under sections referencing this section shall be designed in accordance with applicable portions of ANSI/HI 1.1 – 1.6, 2.1 – 2.6 and ANSI/HI 9.1 – 9.6 and the requirements of this section. The pumps shall be specifically designed to pump the fluid described and shall operate without clogging or fouling caused by material in the pumped fluid at any operating condition within the range of service required.
   1. Unless otherwise noted or specified, pump head capacity curves shall slope in one continuous curve within the specified operating conditions. No points of reverse slope inflection capable of causing unstable operation will be permitted within the zone of continuous duty operation. Pumps with head/capacity curves as described in paragraph 9.6.3.3.12 of ANSI/HI 9.6.3 are specifically prohibited if these characteristics will cause unstable operation within the range of operating conditions

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and where startup/shutdown conditions entail operation against a slow opening/closing valve.

2. Column type (vertical turbine, vertical column solids handling, and axial flow propeller and mixed flow) pumps shall have bells selected to provide a maximum intake velocity of 4.0 feet/second when operating at the maximum design flow or the flow resulting from the lowest operating head at maximum speed, whichever is the greatest ("peak flow").Pump discharge column sizes shall be selected to limit the calculated average velocity at peak flow to no more than 12 feet/second.

C. Critical Speeds and Natural Frequencies: The following criteria shall apply to the equipment in like new condition as well as the as worn condition (i.e., when all parts, individually and as a composite, reach the manufacturers' maximum tolerances).

1. Lateral Rotor Dynamics:
    1. The complete pumping unit, including all related frames, supports, enclosures, and casings, shall be free from dangerous critical speeds from 20 percent below to 30 percent above the operating speeds required to achieve the performance characteristics. The logarithmic decrement for each damped natural frequency (forward or backward) shall be greater than +0.3, and the amplitude magnification factor shall not exceed 3, for any natural frequency within this range.
    2. Operation at infinitely variable speed within the full range of operational conditions is an absolute requirement. Any remedy imposing a locked-out speed interval or intervals will not be acceptable. Combinations of adjustments in rotor geometry or materials, and the substitution of energy absorbing couplings may be allowed to achieve this requirement. Other remedies may be considered so long as they are justified in writing and the proposal sealed and signed by the design professional retained by the manufacturer to perform the system mass elastic system analyses.

2. Torsonal and Combined Shaft Stress:
    1. For constant torque applications, the pump rotor shall be free from torsional response which produces combined (steady plus alternating torque induced) stresses exceeding 30 percent of the material's elastic limit (but no more than 18 percent of the material's ultimate tensile strength) at any speed from 10 percent below to 20 percent above that required by the specified operating conditions, or during startup, shutdown or motor control transients.
    2. For variable torque applications (including variable speed pumps, vertical pumps and pumps with large overhung loads) the pump rotor and any intermediate shafting shall be free from torsional responses which, in accordance with MIL STD 167-2, produce combined (torsional steady and alternating) peak shear stresses at points of stress concentration (calculated in accordance with the requirements of this section) that exceed 4 percent of the material's ultimate tensile strength, nor more than 50 percent of the material's fatigue limit, whichever is less.

D. Impeller Clearances, Vane Passing Frequency and Impeller Keyways:

1. The radial clearance between the tip of the impeller vane and diffuser or volute vanes shall be not less than 3 percent and 6 percent, respectively, of impeller diameter. The ratio of liquid channel widths (diffuser or volute/impeller) shall be not less than 1.15 nor more than

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1.3 for diffuser pumps and 1.4 – 1.5 for volute-type pumps. The pump shall be designed so that internal geometry shall not cause uneven flow distribution at impeller vane inlets.

2. Impeller vane combinations shall not be an even multiple of diffuser vanes in column type pumps.

3. Impeller keyways for multistage column type pumps shall be cut at differing positions and equal angular spacing on the impeller shaft to avoid multiple simultaneous vane passing pulses.

E. Component Design Criteria:

1. General:
    1. Unless otherwise specified, combined stresses in steel frames and supports shall not exceed those permitted by the AISC Manual of Practice - ASD.Combined stresses in cast, forged, rolled, or fabricated pressure retaining components, frames and supports shall not exceed that allowed for the given material in Section VIII, Division 1 of the ASME Code. Design pressures for pressure-retaining parts shall be not less than twice the pump's shutoff head at the manufacturer's listed maximum operating speed. Pump casing strain at any head on the full speed operating curve (including allowances for increases caused by specified multi-stage applications) shall not result in distortions at the bearing frames or housings greater than the maximum allowable by the bearing manufacturer to provide the specified bearing life.
    2. The term "combined stresses" in this section shall mean the sum of all operating stresses, including stresses induced by dynamic and static forces as developed via the analysis procedures stipulated in this section. Static forces (x, y, z, and moments in all planes) shall include the relevant maximum nozzle loads specified in ANSI/HI 9.6.2 or as stipulated by the pump manufacturer. Dynamic forces shall include both steady state and transient stresses induced by operating conditions within the zone of operation established by the specified operating conditions.

2. Anchorage and Equipment Mounts:
    1. Design anchorage and equipment support requirements for pumps to conform to ANSI/API 686 and the standards of the Hydraulic Institute.
    2. Anchor bolts and connecting bolts for all pumps and assemblies supported by other assemblies furnished under this section, or sections referencing this section, shall be designed in accordance with all applicable building codes. All operation and maintenance manuals for all pumps and assemblies shall contain criteria for anchor and baseplate bolt torque values.
    3. Unless otherwise recommended by the equipment manufacturer, all pump discharge nozzles shall be restrained using equipment connection fittings designed for this application.
    4. Equipment mounts for vertical (column and volute type) pumps weighing more than 1000 pounds, with discharge nozzles 6 inches in diameter and greater, shall employ soleplates. Soleplate mounting shall also be provided for all separately supported components in the pump drive system. Fabricated steel supports regardless of design and the nature of the structural shapes used for such proposed supports, will not be accepted.

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5. Soleplates shall be designed to span openings for equipment connections and provide access to maintenance points. Soleplates shall be of sufficient section to key, not less than 1-inch, into the supporting grout provided for bonding the soleplate to the structure. Soleplates shall be of sufficient size to bolt the pump base to the soleplate and allow dowelling the pump base to the soleplate without encumbering the anchor bolts required for clamping the soleplate to the structure.
6. Equipment mounts for horizontal pumps shall be designed in accordance with ANSI/API 610 and shall provide common support for the pump and motor. Baseplate bolting shall conform to assumptions contained in ANSI/HI 9.6.2.Pump base shall be drilled and dowel pinned to the base plate in addition to bolting.
7. Tapered dowel pins shall be used to record the final position of all machine bases on soleplates or pump baseplates. Dowel pins shall be hardened and machine- ground conforming to the requirements of ANSI/ASME B18.8.2.Holes for tapered dowels shall conform to the requirements set forth in Appendix A of ANSI/HI B18.8.2.

3. Torsional and Combined Shaft Stresses: Shaft stresses shall be calculated using the following equation and the stress concentration factors in the table below.

$$S = S_{cf} * (\frac{G * D * \Delta_o}{2L})$$

where:

S	=	stress, psi
Scf	=	stress concentration factor, dimensionless
D	=	minimum shaft diameter at point of concentration, inches
Δ_Θ	=	twist in shaft between adjacent masses, radians
L	=	effective length between masses, inches
G	=	shear modulus of shaft material, lb/in2

The S_{cf}, to be applied at all the roots of all keyways and changes in shaft diameter shall be as follows:

S_{cf}	Ratio of fillet radius to shaft diameter
4.3	0.0025
3.7	0.01
3.05	0.02
2.75	0.03
2.6	0.04
2.55	0.05 and greater

Values of Scf between data points in the table above shall be based upon a straight line interpolation.

4. Shaft Deflection: Pump shafts on volute type pumps shall be designed to provide sufficient stiffness to operate without distortion or damaging vibration throughout the range of

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service specified. Shaft deflection at the face (impeller side) of the shaft seal shall be limited to no more than 1.5 mils at any operating condition within the zone described by the specified continuous duty operating conditions. Deflection at the shaft seal shall be calculated using the relationship set forth herein.

5. Bearings: Unless otherwise specified, anti-friction bearings for pumps below the Size Threshold Criteria shall be selected for an L–10 life of 50,000 hours in accordance with ABMA 9 or 11.Anti-friction bearings for pumps meeting the Size Threshold Criteria shall have bearings selected for an L–10 life of 100,000 hours in accordance with ABMA 9 or 11.Bearings for other elements in the rotating system such as motors, intermediate shaft bearings, and flywheel bearings shall be selected using the same criteria as specified for the pump. Bearing selection shall be based upon the worst combination of continuous duty operating conditions and shall include both steady state and transient loads. Calculations supporting the selection of bearing sizes shall be provided.

6. Bearing Isolators: Unless otherwise approved, all bearings shall be fitted with bearing isolators, specifically selected for the size and type bearing. Bearing isolators shall be labyrinth, non-fretting type designed to expel contaminants by centrifugal force and prevent escape of lubricants. Vapor block capability shall be provided. Bearing seals shall be Inpro/Seal or approved equal.

7. Pump Shaft Seals: Unless otherwise specified in the detailed specification, pump shaft seals shall be water flushed mechanical seals

F. Net Positive Suction Head Margin Limitations:

1. General: Pumps furnished under this section and sections referencing this section shall be selected for NPSH (Net Positive Suction Head) margin limitations using the suction energy methodology set forth in ANSI/HI 9.6.1-2000.Despite the withdrawal of ANSI/HI 9.6.1-2000, procedures referenced in that standard are applicable where specified in this Section. Net Positive Suction Head Required - 3 Percent Reduction (NPSH3) characteristics for the candidate pump shall be based upon documented test data not more than five years old, performed on a pump not more than two nominal pump diameters larger or smaller than the proposed pump with an impeller of the same geometry as that proposed for the pump to be used for the subject application, and operating at the same speed as the pump for the proposed application. Submit documentation for the basis for pump selection based upon NPSH margin limitations as set forth in this paragraph.
    1. Adjust the NPSHA information to the elevation of the pump impeller eye for the specific pump model and size proposed for the application. NPSH3, as used in the following paragraphs, shall mean the NPSH3 at the impeller eye, determined in accordance with ANSI/HI 1.6, 2.6 or 11.6, as applicable for the proposed pump.
    2. Using suction energy rules in selecting pumps proposed for each application, apply criteria set forth in the individual paragraphs below. Percentages stated below shall apply to pump capacity on the selected pump's head/capacity curve at the speed required to achieve the specified operating condition.
    3. Submit the manufacturer's suction energy calculations justifying the proposed pump selection. The NPSH margin ratios specified in this paragraph shall be the minimum acceptable margin ratios. If the proposed pump requires greater margin ratios to operate within all operating conditions without damaging cavitation, achieve the

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required margin ratio by lowering the elevation of the pump setting, lowering the elevation of the structure or other means. Any such adjustments shall be pre-approved by Owner.

4. Individual restrictions that apply to NPSH margin shall be as set forth below, depending upon the type of pumping equipment and the fluid to be pumped.

2. Centrifugal Pumps – Low Margin Ratio: The following restrictions shall apply to pumps classified as centrifugal pumps under ANSI/HI 1.1 – 1.2 with specific speeds less than 7000 and to vertical column-type sewage pumps with specific speeds less than 4000:
   1. A minimum NPSHA/NPSH3 margin ratio of 1.3 shall apply to low suction energy pumps at any operating condition within 85 percent and 115 percent of best efficiency capacity. The minimum acceptable NPSHA/NPSH3 margin ratio at any other location on the pump's head/capacity curve (for low suction energy pumps) shall be 1.8.
   2. Notwithstanding item a., above, the manufacturer shall use the methodology in ANSI/HI 9.6.1 to determine the proposed pump's suction energy based upon the pump's performance at best efficiency capacity and head at the speed required for meeting Condition Point A and B in the detailed pump Section. In determining the proposed pump's suction energy, the inlet nozzle size shall be increased by two nozzle sizes to account for impeller design considerations. In employing the suction energy method, the minimum NPSHA/NPSH3 ratio shall be not less than that recommended in ANSI/HI 9.6.1 or item a., above, whichever is greater. For submersible pumps, suction nozzle size shall be the impeller eye diameter for the proposed pump.
   3. If the proposed pump's suction energy, as determined in item b. falls into the "high" and "very high" region in Figure 3 in ANSI/HI 9.6.1, the minimum acceptable NPSHA/NPSH3 margin ratios shall be 1.5 and 2.0, respectively, for specified operating conditions within the zone defined by ± 15 percent of best efficiency capacity and 2.0 and 3.0, respectively, for specified operating conditions falling outside the ± 15 percent zone.

3. Centrifugal Pumps – High Margin Ratio: The methodology set forth in ANSI/HI 9.6.1 shall be employed for determining NPSH margin for vertical column-type sewage pumps with specific speeds greater than or equal to 4000, other vertical pumps classified under ANSI/HI 2.1 – 2.2, and all pumps with specific speed greater than 7000:
   1. A minimum NPSHA/NPSH3 margin ratio of 2.0 shall apply to low suction energy pumps at any operating condition within 85 percent and 115 percent of best efficiency capacity. The minimum acceptable NPSHA/NPSH3 margin ratio for low suction energy pumps at any other location on the pump's head/capacity curve shall be 2.5.
   2. Notwithstanding item a., above, the manufacturer shall use the methodology in ANSI/HI 9.6.1 to determine the proposed pump's suction energy based upon the pump's performance at best efficiency capacity and head at the speed required for meeting Condition Point A and B requirement of the detailed pump Section .In employing the suction energy method, the suction nozzle size shall be the impeller eye diameter for the proposed pump.
   3. To adjust for impeller design considerations for pumps employed for solids bearing liquids, the inlet nozzle size shall be increased by two nozzle sizes in determining the proposed pump's suction energy in accordance with ANSI/HI 9.6.1.For submersible and column type pumps, suction nozzle size shall be the impeller eye diameter for the proposed pump.

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4. If the proposed pump's suction energy, as determined in item b. falls into the "high" and "very high" region in Figure 3 in ANSI/HI 9.6.1, the minimum acceptable NPSHA/NPSH3 margin ratios shall be 2.5 and 3.0, respectively, for specified operating conditions within the zone defined by ± 15 percent of best efficiency capacity 3.0 and 3.5 respectively, for specified operating conditions falling outside the ± 15 percent zone.

G. Electric Motors:

1. General:
    1. Unless otherwise specified, pumps shall be electric motor driven. All motors shall be selected to be non-overloading at any operating point along the pump's full speed operating curve, including all points located beyond specified operating conditions. All vertical motors shall be solid shaft construction. Hollowshaft motors will not be accepted. Motors furnished with pumps specified for operation at variable speed shall be inverter duty types conforming to the requirements Division 16and shall be compatible with the variable speed equipment furnished with the pump.
    2. Motor bearings shall be protected with bearing isolators.

2. Motors for Custom Engineered Pumps: In addition to the information submitted under the requirements of Division 16,Provide certified reed frequency calculations for both the motor rotor and frame for vertical motors driving custom engineered pumps . Upon completion of construction of motors for custom engineered pumps, each rotor and frame and the completed assembly shall be given a bump test to confirm reed frequency calculations in the dynamic analysis modeling. The results of the bump test, certified by an officer of the manufacturing corporation and notarized, shall be submitted.
    1. All vertical motors shall meet motor face dimension tolerances as follows:

Motor face bolt circle diameter, inches	Motor face runout, inches
12	0.002
16.5 through 24.5	0.002
30 through 42	0.003
42 and larger	0.005

    2. Motor face register concentricity, referenced to the shaft centerline, shall be not greater than 0.002 inches, if the motor is furnished without jack screws. Motor shaft total indicated runout (TIR) shall not exceed 0.002 inches.

3. Balance: Motors rated 50 horsepower and greater, all motors driving custom engineered pumps and all motors operating at less than 1200 rpm shall be precision balanced motors conforming to the requirement set forth in the table below. The Contractor shall provide certified balance logs attesting to achieving these requirements. Displacement readings shall be taken at the shaft with an FFT analyzer at 1X speed. Balance logs shall be notarized and signed by an officer of the manufacturing corporation.

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Speed, rpm	Mils displacement (peak to peak)
3000 and above	0.5
1500-2999	1.0
1000-1499	1.0
<1000	1.5

1.05 ADDITIONAL DESIGN REQUIREMENTS

A. Rotor Critical Speed Analysis and System Design:

1. General: The requirements of this paragraph shall apply to all pumps when the referencing specification section stipulates. The analyses shall be applied to the equipment in like new condition as well as the as worn condition (i.e., when all parts, individually and as a composite, reach the manufacturers' maximum tolerances).

2. Requirements: The complete pumping unit, including rotating elements, frames, supports, and all related structural elements, including pump, motor and bearing supports, shall be subjected to a lateral rotor dynamic analysis, including a rotor dynamic critical speed analysis, to identify and eliminate harmful resonant conditions.
    1. The complete pumping unit rotating element including pump, motor, intermediate shafting and flywheel rotors (if required), and all other elements in the power train (or powered via the power train) shall be designed and manufactured to limit torsional stresses.
    2. Overhung shaft pumps and between bearings pumps operating in single volute casings shall be subject to analysis for shaft deflection in accordance with the terms of this section.

3. Professional Qualifications: Retain the services of an independent professional engineering firm, employing a qualified design professional, which has been engaged in performance of the required, mass elastic design analyses for not less than ten years on equipment of similar size and complexity. The design professional shall not have been in the employ of any pump manufacturer, for a period of not less than 10 years from the date of the request for proposals for this project.

4. Reports, Calculations and Recommendations: All reports, calculations and recommendations resulting from the required analyses shall bear the design professional's original signature and professional registration seal.

5. Methodology:
    1. Lateral Rotor Dynamic Analysis: The rotor dynamic analysis shall follow the procedure prescribed in Corbo and Malanoski, 1998, and shall include the following features:
        1) The procedure shall consider all speeds required to operate the equipment within the envelope of specified continuous operating conditions specified.

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2) The procedure shall produce Campbell diagrams for the proposed operating conditions depicting all potential sources of excitation to check interference with all relevant frequencies up to, and including, not less than 6 times (6X) operating speed.
3) For all pumps, the analysis shall also consider vane pass excitation at rev/2.
   a) For column type pumps only, the procedure shall consider variations in asssumed coefficients for seal and wearing ring clearances (Lomakin effect), bearing stiffness and damping, rotor imbalance (up to 10 percent of rotor disc weight at each disc position), impeller destabilizing forces, rotor shaft bending, hydraulic imbalance at not less than five operating conditions within the envelope of continuous operating conditions specified in addition to the specified continuous operating conditions.
   b) Unless specifically pre-approved by Owner, the range in variation of component characteristics shall comply with the ranges recommended in Corbo and Malanoski, 1998.
4) The mathematical modeling tools to be employed for the analyses and the procedure to be used shall be as described in the references specified for the Lateral Rotor Dynamic Analysis Methodology with the following modifications:
   a) The mathematical model of the rotating element shall be built on a rotor dynamics code such as FEATURE or DYROBES. Use of a finite element modeling program for this purpose will be unacceptable. The model shall specifically be constructed to contain axisymmetrical models of the rotor and casing. This model shall be used to determine the natural frequencies of the rotating elements.
   b) A finite element code such as NASTRAN or ANSYS shall be used to construct three dimensional models of the casing and support structures for the equipment furnished under this contract. This model shall be used to determine the natural frequencies of the support structures and casing as well as the pump bearing frames.
   c) The axisymmetrical model shall then be adjusted, preferably by changing component materials or sizes, or by changing component type, until its output frequencies agree with the models constructed under b).
5) Physical adjustments to provide the required characteristics shall be preferably by changes in component dimensions and secondarily by providing torsionally resilient dampening devices such as fluid-damped couplings or all metallic couplings such as manufactured by Bibby and Holset.Couplings or dampeners using rubber or similar elastic materials shall not be used.
6) The final report shall include three-dimensional graphic presentation of frame and shaft distortion and rotor element performance at identified critical speeds within the pump's operating range.

2. Torsional Dyanmic Analysis:
   1) The methodology used for evaluation of the mass elastic system and shaft combined stresses shall follow the approach prescribed in Corbo and Malanoski, 1996, using either the Matrix-Eigenvalue or Holzer methods for determining natural frequencies. The computer analysis results shall be verified by hand calculations for the fundamental frequency and for mode shapes. Exciting frequencies to be considered during the analysis shall be 0.5, 1, and 2 times running speed, vane passing frequencies and twice vane passing frequencies for the pump impeller/cutwater-diffuser vane combinations, line and twice line

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frequency, motor pole frequency and motor starting transients. Forcing function magnitudes used for the analysis shall be not less than 10 percent of the maximum transmitted torque. The analysis shall also include evaluation of control pulse frequencies induced by variable frequency drives or engine power stroke frequencies, if provided as part of the specified system. The analysis report shall include a statement produced by the variable frequency drive manufacturer detailing all control pulse frequencies generated by the equipment between 1/4 and 18 times motor running speed.

2) Unless otherwise justified by documentation supported by independent studies, the analysis procedure shall use the range of factors recommended in Corbo and Malanoski, 1996.Produce a Campbell-type interference diagram showing the relationship between operating range, natural frequencies and exciting frequencies with all relevant frequencies up to, and including, not less than 6 times (6X) operating speed. The stress analysis procedure shall be based upon a finite element analysis technique using a digital computer program that has been field calibrated with not less than five similar installations

3) The analysis shall include a time-integration study showing transient peak stresses resulting from startup, shutdown and motor control transients if synchronous drives are specified. The diagrams shall include calculated stresses throughout the range of frequencies considered in the analysis. Tomographic diagrams, displaying colorimetrically stresses at all positions in the pump shaft and all frames, including roots at changes in section and keyways or other stress concentrating locations, shall be provided with the analysis report. The diagram shall indicate operating speeds identified that produce the peak stresses and shall be specific for speeds inducing identified peak stresses at keyways, changes in section and at connections to other components. The reported stresses shall be combined stresses incorporating all identified loads from torsional, lateral and hydraulic sources.

3. Shaft Radial Load and Deflection:

1) Overhung Shaft Pumps: Shaft radial loads and deflection for overhung shaft pumps operating in single volute casings shall be calculated using the following relationship:

where:

Δ_{max}	=	deflection, inches, at the outboard (impeller side) face of the shaft seal
E	=	modulus of elasticity, psi 30 x 106 for carbon steel, 28 x 106 for 316 for stainless steel Alternate materials: as accepted by Construction Manager
A	=	shaft length, inches, from the centroid of the impeller profile (from inlet to discharge nozzle) to the centerline of the radial bearing
b	=	shaft length, inches, from the centroid of the impeller profile (from inlet to discharge nozzle) to outboard (impeller side) face of shaft seal
c	=	shaft length between centerline of bearings, inches
I_a	=	moment of inertia of the shaft at section a, in4
I_c	=	moment of inertia of the shaft at section c, in4
R	=	radial load, pounds, at any specified operating condition or any operating condition within the envelope of specified operating conditions resulting in peak loads imposed on the shaft:

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$$R = (K)\,(H)\,(D)\,(Y) + W$$

where:

K = Radial thrust factor. K for single volute pumps shall vary with flow and specific speed in accordance with the following:

Q/Q_{BEP}	K, N_S = 2000	K, N_S = 3500
0.0	0.31	0.38
0.1	0.30	0.375
0.2	0.28	0.36
0.3	0.26	0.345
0.4	0.24	0.325
0.5	0.22	0.3
0.6	0.18	0.27
0.7	0.15	0.23
0.8	0.12	0.185
0.9	0.08	0.14
1.0	0.05	0.09
1.1	0.06	0.12
1.2	0.11	0.17
1.3	0.20	0.25

Notes:

a) Q/QBEP in the table is the ratio of flow at the operating condition to flow developed by the pump at best efficiency
b) NS in the table is specific speed, as defined in ANSI/HI 1.1 - 1.6.
c) K for pumps with specific speeds between 2000 and 3500 shall be established by a straight line interpolation from the above values.
d) K for pumps with specific speeds greater than 3500 shall be established by a straight line extrapolation from the above values.
e) K for double volute pumps shall be not less than half the values in the above table, as determined by the application of the rules in notes 3 and 4.
f) The manufacturer is at liberty to use differing values of K from that stipulated above so long as they are greater than those listed in the table. Under no circumstances will lesser values of K be acceptable.

H = Head (psi) developed by the pump at any specified duty point, including operating conditions within the envelope of conditions specified.
D = Mean impeller diameter, inches
Y = Impeller width, inches, at discharge, including shrouds
W = Impeller weight with wearing ring, pounds (W = 0 if vertical pump)

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2) Radial loads calculated in accordance with the above procedure shall be used for bearing life. Flexural stress calculations shall be based upon the loading criteria specified above and shall be incorporated into the combined stress calculations.
3) Impeller Between Bearings Pumps: Shaft deflection for single volute pumps with the impeller mounted between bearings such as for split case centrifugal pumps shall be calculated in accordance with the following formula:

$$\Delta_{max} = (R * x) * \frac{3 * L^2 - 4 * x^2}{48 * E * I}$$

where:

Δ_{max}	=	deflection, inches, at the face (impeller side) of the shaft seal
R	=	radial force, as defined above
L	=	distance between bearings, inches
E	=	modulus of elasticity for the shaft material, as defined above
I	=	shaft moment of inertia at the bearings, inches4
x	=	distance between bearing and seal face (impeller side), inches

B. Suction Wells for Column Pumps: Where a column type pump is to be installed in a suction or inlet well, the manufacturer shall design and furnish the well. The design shall include an arrangement that results in acceleration of flow down the suction well and into the cone. These provisions, however, shall not be construed as relieving the Contractor of responsibility for this portion of the work. Inlet wells shall be designed in accordance with the requirements of ANSI/HI 9.8 and design documentation shall be provided as a part of the information to be submitted as required herein. Designs of inlet suction wells for pumps meeting the Size Threshold Criteria shall be verified by physical model tests on ducted in accordance with ANSI/HI 9.8.

1.06 QUALITY ASSURANCE – ALL PUMPS

A. Quality Certification: All manufacturers and manufacturing sites for supply of equipment furnished under this section and sections referencing this section shall hold current certification under ISO 9001.Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized. The documentation shall also include the manufacturer's written Quality Assurance/Quality Confirmation (QA/QC) program and the documentation plan necessary for ISO 9001 certification.

B. Performance Confirmation:

1. Hydrostatic Tests: Hydrostatically test all pressure sustaining parts at the factory prior to shipping. Hydrostatic tests shall conform to the requirements of paragraph 7.3.2 of ANSI/API 610.

2. Performance Guarantee: Unless specified otherwise pump performance, including efficiency and NPSH3, shall be guaranteed by the pump manufacturer to the criteria specified under this paragraph.

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1. Equipment performance documentation, including test data, where tests are specified, shall include sufficient test points (not less than 8) to document peak efficiency at full speed within a tolerance of minus 0 percent, plus 2 percent. For column type pumps, performance documentation shall include curves showing both bowl efficiency and overall efficiency (including inlet, bowl, column and discharge head losses) at maximum operating speed for the application.
2. Acceptance criteria for head and capacity test results, based upon the rated condition specified in the detailed specification shall be:
    1) At rated head: 95 - 105 percent rated flow.
    2) At rated flow: 97 - 103 percent rated head.
3. In the above acceptance criteria, one value may be less than specified, but not both. Put differently, head may be less than the value specified in the detailed specification, but the pump capacity at that head may not be less than that specified in the detailed specification; and, vice versa, provided that no deviation within the stated acceptance margins shall result in power requirements that exceed the nameplate rating (1.0 service factor) specified for the driver and no power requirement at any head on the full speed head/capacity curve shall exceed the driver nameplate rating (1.0 service factor).
4. Acceptance criteria for NPSH3 at any specified operating condition shall be the values proposed in the submitted performance curves with a tolerance of plus 0, minus unlimited, with the exception that Suction specific speed, as calculated for the specific pump, shall not exceed the limitations specified herein.
5. The guarantee shall include a statement to the effect that the pump will operate within the operating regions specified in the detailed specification, within meanings as defined in ANSI/HI 9.6.3.The guarantee shall be in writing, shall be signed by an officer of the manufacturing corporation, and shall be notarized. Under no circumstances shall deviations from specified operating conditions result in overload of the driver furnished with the equipment, nor shall such deviations result in power requirements greater than the driver's nameplate (1.0 service factor) rating.

3. Factory Tests:
    1. Unless specified otherwise, all pumps shall be performance tested in accordance with ANSI/HI 1.6 (centrifugal pump), 2.6 (vertical pump), or 11.6 (submersible pump), as applicable, to the criteria specified herein. The factory tests shall include test data for each full speed performance requirement (Condition Points A and B of the detailed pump Section) and any other points stipulated for this test procedure in the detailed specification. These tests shall be conducted with the pump inlet throttled to provide the specified NPSHA. For large column pumps, model performance testing with reduced NPSHA, pursuant to Section 11050, may be used. If specified in the detailed specification, test data at the full speed operating conditions shall include shaft vibration and case noise.
    2. The test setup in the manufacturer's test facility shall duplicate as closely as possible the inlet conditions in the proposed installation, using temporary baffles and other means. Where centrifugal pumps are furnished with inlet elbows, inlet adapters or inlet reducers, the pumps shall be tested with the elbow, adapter or reducer fitted to the pump and specified performance criteria shall apply to the complete pump assembly, including losses through any elbow, adapter or reducer. Where submersible pumps are to be furnished with inlet nozzles and/or discharge elbows or adapters, the pumps shall be tested with these components fitted to the pumps. The specified

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performance requirements shall apply to the complete pumping assembly including any inlet nozzles, and discharge elbows or adapters. Certified test data shall include separate readings for inlet and discharge head for each data point.

3. Not less than eight test points shall be taken, including not less than three within ± eight percent (in terms of rated flow) of the rated condition and not less than two test points within±4 percent of the pump's best efficiency point at the test speed. In addition, one test point shall be sufficient to define head and power requirements at shutoff head.
4. NPSH3 tests shall be performed to confirm the data used to establish NPSHA margin for each specified operating condition as specified in paragraph 11050-1.04 F.NPSH3 tests for column type (axial and mixed flow and vertical turbine) pumps shall be performed using the method described for Figure 2.74 or Figure 2.75 in ANSI/HI 2.6.NPSH3 tests for submersible wastewater pumps shall be performed using the method described in Figure 11.6.8 in ANSI/HI 11.6.All NPSH3 tests shall extend from 30 percent to 140 percent of Best Efficiency Flow at full speed, or to not less than 10 percent (in terms of flow) past the flow at Operating Condition B, whichever is greater. Failure to achieve specified performance or performance proposed in accepted submittal documents (capacity and head, efficiency or NPSH3), whichever is more restrictive, shall be cause for rejection. Acceptance tolerances shall be as set forth herein.
5. All test procedures shall be in strict conformance with the referenced standards, except prediction of performance of a trimmed impeller from test data of the larger impeller will not be permitted. If trimming is required, the pump shall be retested. Under no circumstances shall deviations from specified operating conditions, though allowed by the referenced standards, result in overload of the driver furnished with the equipment, nor shall such deviations result in power requirements greater than the driver's nameplate (1.0 service factor) rating.
6. Furnish Owner with not less than two weeks' advance written notice of the date and place of the factory tests.
7. All test results, including test logs and generated curves, shall be certified correct by an officer of the pump manufacturer's corporation and shall be notarized. Submit test results.

4. Confirmation of Passage Geometry: For solids handling pumps, the design waterway passages and mating passages between rotating and stationary portions of such passages shall be subjected to confirmation that no mismatch of exiting and entering angles or angular discontinuities exist in all pumps furnished meeting the Size Threshold Criteria.

1.07 SUBMITTALS

A. In addition to any material listed in the detailed specification, the following submittals shall be provided:

1. Documentation of successful proven pump designs. Documentation shall include applications where pump cans of a similar size have been provided as part of the design, if applicable.

2. Documentation of certification in accordance with ISO 9001.

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3. Predicted pump performance curves for normal operation points showing head, power, efficiency, and NPSH required on the ordinate plotted against capacity (in mgd) on the abscissa. Curves for variable speed pumps shall be provided to demonstrate operation at all speeds required to achieve reduced speed operating conditions. All curves shall clearly display the specified operating conditions and the manufacturer's limits for the POR and AOR. Curves for column type pumps shall show bowl efficiency and allowances for inlet, column and discharge head losses separately.

4. NPSH margin calculations performed for each specified operating condition.

5. Motor submittal information including certified calculations for motor rotor and frame reed frequencies, as applicable.

6. Drawings showing general dimensions and confirming the size of pumps, motors, drives and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; materials of construction, required equipment access and clearances; and weight of equipment.

7. Variable-speed drive information if the equipment specified includes variable speed capability.

8. Driver unit support calculations and data if the driver is separately supported and if the Rotor Critical Speed Analysis has been required by the terms of these specifications.

9. Shaft deflection calculations to demonstrate compliance if shaft deflection calculations have been required by the terms of these specifications.

10. Detail drawings of the pump and driver unit foundation demonstrating conformance to this Section. Submittal shall include drawings depicting type, size, number, projection, and arrangement of anchor bolts, dimensional drawings of the sole and baseplates, dimensional drawings for the concrete supports for both the pump and motor, if applicable. Drawings shall also depict all other pertinent information, including: location of equipment pads and reinforcement; equipment drains; expansion joint locations; elevation of top of grout and grout thickness; elevation of top of baseplate; soleplate; or mounting block; size and location of electrical conduits; and any other equipment mounting features embedded in equipment pads.

11. Limiting nozzle loading criteria, if different from that established by ANSI/HI 9.6.2.Also submit nozzle loading information.

12. Factory and Field Test Reports.

13. Performance guarantees.

14. Equipment anchor calculations.

15. Operation and maintenance information: Level 1 service manuals conforming to Appendix 9 –MPT Operations Manuals. Standard operations and maintenance instructions typically provided by equipment manufacturers will not be accepted as fulfilling this requirement.

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16. Motor Product Data.

17. Bearing L-10 life calculations.

18. Critical speed calculations demonstrating compliance with either the lateral rotordynamic analysis if required. Otherwise, critical speed calculations demonstrating compliance with paragraph 1.4 C shall be submitted.

19. Motor balance logs, certified and notarized.

20. Certified balance logs and worksheets.

21. Pump inlet well installation acceptance certification, if applicable.

22. Field vibration test reports.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Where this section and sections referencing this section are silent with respect to materials of construction on any component, material selection shall follow the requirements of Table H.1, ANSI/API 610, Materials Class I-1, with the exception that all shafts for vertical column type pumps shall be 12 percent chromium stainless steel. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion.

B. Pumps:

1. Finish for Surfaces in Contact with Pumped Fluid: All pump components in contact with the pumped fluid shall conform to the following requirements:
    1. Surfaces to be machine-finished shall be indicated on the shop drawings by symbols which conform to ANSI B46.1, Surface Texture, Surface Roughness, Waviness and Lay. Machine surfaces shall be finished to at least the following tolerances (SI units):
        1) Surface - Nominal Roughness Grade, Ref: ANSI B46.1 (SI units)
        2) General Machine Work 3.2 or better
        3) Flange Faces 3.2
        4) Journal Surfaces at Sleeve Bearings 0.4
        5) Hydraulic Surfaces
            a) Impeller 4.5 or better
            b) Impeller Bowl and Diffuser 3.2 or better
            c) All other wetted surfaces 6.3 or better
    2. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable will be cause for rejection. Machine finished surfaces shall be thoroughly cleaned and coated with protective layer of rust preventive. Small pieces, unassembled pipe or finished bolts, shall be oiled and wrapped with moisture resistant paper.

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2. Materials: Unless otherwise specified, wetted cast iron parts for pumps for solids bearing liquid services shall have 2 to 3 percent nickel added to the cast iron.
    1. Stainless steel impellers shall be provided for pumps intended for pumping screened or unscreened wastewater and elsewhere when specified. Stainless steel impellers shall be cast duplex stainless steel conforming to ANSI/API 610, Materials Class D-1 ("DUPLEX" with Charpy impact energies greater than 40 ft- lbs at -40°C per ASTM A923 method B).Where cast nickel aluminum bronze (C95800) impellers are specified, the materials shall conform to ASTM B148.Unless otherwise specified, second and successive stage impellers on multistage column pumps may be porcelain coated cast iron or bronze.
    2. Materials for all shaft sleeves for packed boxes, fretting seals and interstage seals shall conform to ANSI/API 610, Annex H, Materials Class S-6 or S-8; 12 percent chromium hardened; or hard-faced 316 austenitic stainless steel.Materials for seal glands for packed boxes and shaft sleeves shall be AISI 316 stainless steel. Fastener parts of all types in wetted areas shall conform to ANSI/API 610, Annex H Materials Class S-5 requirements. Regardless of the seal construction, all seal chambers shall be adequately sized to accommodate specified mechanical seals.

2.02 GENERAL QUALITY

A. Details of manufacture and assembly of equipment furnished under this section and referencing sections shall follow the requirements of ANSI/API 610 with respect to the following features (paragraph references, ANSI/API 610):

1. Alignment aids (paragraph 5.1.26).

2. Removal of rotating element (paragraph 5.1.27).

3. Jackscrews for assistance in alignment on all baseplates and equipment supports (paragraph 8.3.8.3.2).

4. Castings (paragraph 5.12.2).

B. All components or subassemblies weighing 50 pounds or more shall have at least one lifting eye or a provision for threading in a lifting eye. Components 250 pounds or greater shall have lifting eyes or provisions for at least two lifting eyes. Components 1000 pounds or greater shall have at lest 3 lifting eyes or provisions for inserting lifting eyes.

2.03 BASEPLATES AND SOLE PLATES

A. Unless otherwise noted in the detailed specification, all pumps shall be furnished by the pump manufacturer with baseplates or soleplates. Baseplates and sole plates shall be designed to be installed in the housekeeping curb shown and shall be machined flat and co-planar to within 0.002 inch per foot in all directions on the face mating with the pump and motor or driver support. Sole plates shall have the words "THIS SIDE DOWN" permanently affixed to the underside using welding rod material prior to milling. Alternative marking methods, using heavy scribing or machining, are acceptable provided that they may be observed following blasting in preparation for coating.

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2.04 WEARING RINGS

A. Where specified, pumps shall be fitted with both stationary and rotating wearing rings. Except for the difference in hardness between stationary and rotating rings, wearing rings shall be of ASTMA276 Type 420 stainless steel and shall conform to the requirements of ANSI/API 610, paragraph 5.7.Maximum wearing ring clearances shall not exceed 150 percent of the values stated in Table 5, ANSI/API 610. Minimum wearing ring hardness on the rotating ring shall be 350 Brinnel Hardness Number (BHN), with the stationary ring not less than 100 hardness points greater.

B. L-form wearing rings are not acceptable for wastewater, sewage, stormwater, thickener overflow, mixed sludge, digester circulation, digested sludge, waste activated sludge, return activated sludge or primary effluent pumping service.

2.05 BALANCE

A. Balancing for pumps with suction nozzle sizes 6 inches in diameter and greater and all associated components shall conform to the requirements set forth in ANSI/API 610, paragraph 5.9.4.1 (equivalent to ISO 1940 or ANSI 2.19 Grade 2.5), unless other portions of this project manual impose more restrictive requirements. Major rotating elements (e.g. impellers) and shafts shall be separately balanced and then together as an assembly or "rotor."All rotors shall be dynamically balanced to an ISO 1940 G6.3 minimum for rotating speeds up to 1800 RPM. Speeds above 1800 RPM shall have an ISO 1940 G2.5 minimum balance quality if impeller weight exceeds 100 lbs. Impellers larger than 24 inches in width along the shaft centerline shall be two plane balanced..For extended shaft pumps, the rotor is defined to be the impeller(s) and shaft(s) up to the first coupling with the line-shaft.

B. All balance logs, certified correct and signed by an officer of the manufacturing corporation and notarized, shall be furnished.

2.06 DRIVE UNIT SUPPORTS FOR SEPARATELY SUPPORTED MACHINES AND INTERMEDIATE SHAFT SUPPORTS

A. Supports for separately mounted vertical pump drivers and intermediate shaft bearings shall be composite structures of fabricated steel, ASTM A36.Unless otherwise specified, the supports shall be designed to span an opening in the floor sufficient to allow removal for the complete pump. Rolled steel beams shall be provided to stiffen the support and a fabricated steel driver unit support pedestal shall be mounted on the support plate. The support pedestal top plate and all portions of the support plate assembly intended to join with surfaces in the installation structure shall be milled flat and parallel to 0.002 inches per foot. Pedestals shall be provided with access provisions to adjust or assemble/disassemble couplings. The support shall be designed to be supported on a sole plate or sole plates embedded in a house keeping pad at the edges of the floor opening or as indicated.Other details for the driver unit support shall be as indicated.

2.07 INLET WELLS FOR COLUMN TYPE PUMPS

A. Unless specified otherwise, suction or inlet wells where used by the Contractor for column type pumps shall be fabricated from Type 316 Stainles Steel with internal baffles fillet welded to the

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interior surface of the inlet well. Seal welds all around shall be provided at all welded joints and all welds shall be ground smooth..

B. Where design requires an inlet well suitable for service with an upstream hydraulic gradient in excess of the elevation required for the pump discharge head, the flanged connection to the pump discharge head shall be gasketed or fitted with a double O-ring seal designed to withstand not less than twice the pressure specified in the detailed specification

PART 3 EXECUTION

3.01 GENERAL

A. With the exception of submersible pumps and the inlet connection for column type pumps installed in open forebays or wet wells, all pump inlet and discharge nozzles shall be connected to field piping using equipment connection fittings. Restraining rods on equipment connection fittings shall be designed specifically to restrain the unbalanced hydraulic thrust developed by the pump when operating at full speed against a closed valve. All restraining rod nuts shall be torqued to assure that any moment or shear transmitted to the pump nozzles is within the values permitted under ANSI/HI 9.6.2 or that permitted by the equipment manufacturer, whichever is greatest. Where ANSI/HI 9.6.2 is silent with respect to any particular aspect of allowable nozzle loads, the Contractor shall follow the written requirements provided by the equipment manufacturer. Equipment meeting the Size Threshold Criteria shall be installed under the presence of a factory authorized installation specialist or specialists. Under no circumstances shall any installation procedures take place without the installation specialists present.

3.02 SOLE PLATES

A. Sole plates, if provided as required by this section, or any section referencing this section, or where required by the equipment manufacturer's recommendation, shall be leveled in the presence of a factory authorized installation specialist to a maximum tolerance of 0.002-inches/foot in all directions. Where the equipment manufacturer requires more stringent tolerances, those tolerances shall prevail.

3.03 PUMP INLET WELLS

A. When provided by the Contractor, pump inlet wells shall be installed in accordance with the following tolerances:

1. Horizontal position:± 0.125 inches in all directions

2. Vertical axis: within ½ degree from vertical

3. Level:0.02 inches per foot of diameter at the pump baseplate bolt circle

4. Elevation:± 0.125 inches from planned elevation

B. Where the equipment manufacturer requires more stringent tolerances, those tolerances shall prevail.

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C. Installation of equipment in pump inlet wells shall not take place until the pump manufacturer's factory trained and authorized installation specialist has furnished written and signed certification that the inlet well has been installed satisfactorily and is acceptable for installation of the equipment.

3.04 ALIGNMENT

A. Journeymen millwrights shall perform alignment of equipment furnished under this section and any referencing section. Carpenters, laborers or any other trades are specifically excluded from performing this work. In locations where such trades are not available, the Contractor shall retain the services of a firm specializing in this type of work to perform the setting and alignment work. Alignment shall be conducted after grouting baseplates or sole plates in place.

3.05 FIELD TESTING

A. Field testing shall be required for all units meeting the Size Threshold Criteria, the testing procedure shall be a plan developed jointly by the Contractor and the equipment manufacturer to demonstrate performance of each item of equipment at all specified operating conditions.

B. Field testing may include vibration and torsional vibration testing, as applicable.

3.06 FIELD VIBRATION

A. General:

1. Vibration shall be measured in accordance with ISO 10816 for all pumps meeting the Size Threshold Criteria. An independent testing laboratory specializing in this work, retained by the Contractor but acceptable to Owner, shall perform the measurements and shall submit the results directly to the Owner.

2. The independent laboratory shall provide the services of a vibration specialist to supervise all data collection work, analysis and reporting, and who shall hold a current certificate as an ISO qualified - Level IV Vibration Analyst as recognized by the Vibration Institute. Data collection and analysis shall be conducted by the vibration specialist or may be conducted by an individual holding a current ISO Level III Vibration Analyst certificate with vibration specialist oversight.

3. The independent testing laboratory shall be fully equipped to provide continuous velocity and displacement values for all rotating equipment installed under the requirements of this section. Vibration readings shall be taken at all bearing pedestals in the horizontal and vertical radial direction and axial direction. All vibration measurements and equipment settings should be per procedures advocated by the vibrations institute.

B. Pumps:

1. Vibration testing equipment shall include sufficient calibrated pressure and flow monitoring devices to determine pump operating conditions as well as vibration levels. Overall (RMS) vibration velocity and discrete frequencies, when the pump is operating at

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any specified continuous duty operating condition, shall not exceed the limits established for the appropriate machine by tables 7 and 8 in ANSI/API 610.

C. Pump Drive Train Components:

1. For pump drive train components such as motor/driver, flywheel, gear reducers and other auxiliary components, vibration limits shall be determined in accordance with ISO 10816, with the acceptance vibration limits per machine class, as follows
    1. 0.03 in/sec RMS for Class I (small machines with electric motors up to 15 kilowatts/20 HP
    2. 0.04 in/sec RMS for Class II (machines with 15-75 kilowatt/20-100 HP electric motors and 300 kilowatt/400 HP engines on special foundations).
    3. 0.07 in/sec RMS for Class III. (>75 kilowatt/100 HP) mounted on heavy, rigid foundations.

2. Axial readings shall not exceed one half any radial reading. Machines equipped with rolling element bearings shall be per ISO 10816 excluding Part 7.

D. Reports:

1. Vibration test reports shall bear the signature of the responsible vibration specialist. Vibration spectra shall be of sufficient resolution for legibility of magnitude and frequency data to be properly reviewed by the Owner. Cascade diagrams are not sufficient for variable speed drive application unless supported by the required data in a format suitable for more detailed analyses. Separate spectra shall be provided at the maximum and minimum operating speeds and any potential resonant frequencies.

3.07 FIELD TORSIONAL VIBRATION TESTING

A. Where required by these specifications, field torsional vibration tests shall be performed under the direct supervision of the design professional responsible for the mass elastic system design on a pumping unit preapproved by Owner.

3.08 TRAINING

A. Training shall conform to the requirements of Division 01 and shall include separate training sessions for each operator shift maintained by Owner and a separate session for maintenance personnel. Unless otherwise specified in the referencing section, the training requirement is waived for constant speed pumping equipment with suction nozzle sizes 6 inches in diameter and smaller and for all pumps with connected power requirements 10 horsepower and less. The training session for maintenance personnel shall include a comprehensive presentation, employing cut-away models or comparable graphics, and documentation on the step-by-step disassembly and subsequent reassembly of a pumping unit. Upon completion of all training requirements, the Contractor shall submit a form certifying his compliance.

END OF SECTION

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SECTION 11243
DEWATERED SLUDGE STORAGE BINS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section includes two field erected, live bottom type, non-pressure, welded steel pre-dewatered cake storage bins and accessories. Pre-dewatered sludge storage bin accessories shall include the following.

1. Bin high level switches (two per bin)
2. Bin ultrasonic level detector (two per bin, to be provided by others)
3. Access hatch at the top of the bin (one per bin)
4. Manway near the base of the bin (one per bin)
5. Bin load cells (number required to be verified by bin manufacturer)
6. 8" diameter odor control connection at the top of the bin (one per bin)
7. 8" diameter fresh air inlet connection at the top of the bin (one per bin)
8. [X" by X"] rectangular pre-dewatered sludge discharge connections at the top of the bin (four per bin). The exact dimensions and locations of these connections will be determined during the shop drawing submittal process.
9. Live bottom discharger unit (one per bin) consisting of four bottom feeder screws and either two or four close coupled integral gear motors and VFDs
10. Live bottom discharge chute connecting to the inlet hopper of each THP feed pump (two per bin)
11. Live bottom discharge chute motor operated slide gates (two per bin)
12. Emergency stop devices (two per bin)
13. Spare parts as specified herein.

Comment [TJN1]: Numbers to be entered after THP System Supplier selection.

B. Controls: The control logic, monitoring, interlocks, input and output signals are routed through and reside in the Process Control System (PCS), which is external to the cake bin system. Field mounted instrumentation and controls shall be wired through the respective VFD where it can be accessed by the PCS, or directly to the PCS. Safety devices and interlocks shall be hardwired to the VFD for shutdown of equipment.

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1.02 REFERENCES

A. This Section incorporates the requirements in the documents listed below by reference. Where a referenced document contains secondary references to other standards, those documents are included herein as if referenced directly. In the event of conflicts, requirements stated explicitly herein take precedence over requirements in listed references which in turn take precedence over requirements in secondary references.

B. The following references identify codes and standards applicable to pre-dewatered cake bin system equipment:

1.	ASTM A36	Carbon Structural Steel
2.	ASTM A276	Stainless and Heat Resisting Steel Bars and Shapes
3.	ASTM-A322	Steel Bars, Alloy Standard Grades
4.	ASTM-A480	Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
5.	ASTM-A554	Welded Stainless Steel Mechanical Tubing
6.	IBC Chapter 16	Structural Design
7.	ANSI - B20.1	Safety Standards for Conveyors and Related Equipment.
8.	ABMA-9	Load Ratings and Fatigue Life for Ball Bearings
9.	ABMA-11	Load Ratings and Fatigue Life for Roller Bearings
10.	ASME – Section IX	Welding and Brazing Qualifications
11.	AWS D1.1	Structural Welding Code
12.	CEMA 350	Screw Conveyors
13.	NEMA ICS2	Industrial Control Devices, Controllers, and Assemblies
14.	NEMA ICS6	Enclosures for Industrial Controls and Systems
15.	NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
16.	NFPA 70	National Electric Code (NEC)
17.	NIST Handbook 44	Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices
18.	OSHA 1910	Occupational Safety and Health Standards

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C. Other technical specifications specifically related to this specification include:

1. Section 11000 General requirements for equipment

2. Section 16150 Motors

1.03 SYSTEM DESCRIPTION

A. Design Requirements: The cake storage bins shall receive waste activated sludge (WAS) that has been screened to remove solids larger than 5mm, then dewatered by the pre-dewatering centrifuges to a solids concentration ranging from 15% to 22%. Two pre-dewatering centrifuges are dedicated to each bin, with each centrifuge capable of discharging to the other (non-dedicated) storage bin by means of an electrically driven conveyor. Each pre-dewatering centrifuge has a throughput capacity of approximately 1,000 to 1,200 dry lbs/hr with a 95% minimum solids capture. With all three duty centrifuges operating, the maximum sludge flow to a single bin will be approximately 3,000 to 3,600 dry lbs/hr per cake storage bin. A live bottom discharger mounted at the bottom of the cake storage bin delivers dewatered sludge to progressive cavity pumps for transfer to a thermal hydrolysis process (THP) that precedes anaerobic digestion.

Comment [TJN2]: Range will be more precise after THP System Supplier selection.

B. Performance Requirements: Cake bins provide a separate control point to adjust THP throughput independently from levels in the WAS storage tank. The storage capacity of each bin holds sufficient sludge solids to maintain operation of the THP process for approximately 6 hours at ultimate (phase 2, year 2040) maximum month flow rates; this equates to 12 hours of combined storage between the two bins.

1.04 SUBMITTALS

A. Product Data: Provide product data for all elements listed in Paragraph 1.01A.

B. Shop Drawings: For all elements listed in Paragraph 1.01A, include outline dimensions and weights, general arrangement, installation plans and sections, assembly drawings, anchorage requirements, and support requirements.

1. Provide wiring diagrams and wiring connection diagrams for all equipment, including level sensors, level switches, emergency stop switches and pushbuttons, gate operators and load cells and transmitters, and bin drive motors and accessories.

2. Provide mounting details for level sensors and level switches.

3. Provide mounting and configuration details for discharge gates.

4. Provide mounting details for load cells and associated transmitters.

C. Working Drawings: Coordinate interconnection with cake conveyance chute, sludge cake transfer pumps, and odor control ductwork. Detailed information on coordination items will be provided to the cake bin manufacturer by the THP System Supplier.

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D. Quality Control Submittals:

1. Design Data: Weights, dynamic loads, hydraulic storage capacity, solids storage capacity, conveyor volumetric capacity, and conveyor turndown ratio.

2. Test Reports: Pre-start documentation and reports generated in field, functional, and performance testing in accordance with Appendix XX.

3. Certificates: Materials compliance for bin shell, stiffeners, supports, conveyors, and accessories. Design conformance to IBC Chapter 16 and OSHA 1910. Conformance of load cell NIST Handbook 44 classification.

4. Qualifications Data: Installation list with number of units, size and model of each unit, number of years in operation, and contact information.

5. Manufacturer's Instructions: Installation and Start-up Instruction Manuals

6. Manufacturer's Field Reports: Service representative reports conforming to Section 01665 – Equipment Testing and Startup.

7. Evidence of ISO 9001:2008 certification or a written quality assurance, quality control plan.

E. Other Submittals:

1. Motor data conforming to requirements of Section 16150 – Motors.

2. Instrument data conforming to requirements in Section 13300 – Instrument and Control General Provisions.

3. Programming Input: Monitoring and control narrative corresponding to logic developed in PCS programming.

4. Operating and Maintenance Data: In accordance with Section 01730.

5. Warranty: In accordance with Section 01740. Furnish a letter from equipment manufacturer confirming proper installation, proper commissioning, performance limits, covered components, and warranty effective dates.

1.05 QUALITY ASSURANCE

A. Equipment manufacturer shall be ISO 9001:2008 registered or have a written quality assurance, quality control plan and have no less than five installations in the United States using the same or similar type and size of equipment that has been operating successfully for a minimum period of three years (15,000 hours each minimum).

B. The Pre-Dewatered Cake Bin Supplier shall provide qualified representatives to the site, summarized herein. The supplier shall indicate, in his quote to the General Contractor, the

Comment [TJN3]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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number of on-site man-days and the number of trips to the worksite necessary for the supplier to perform the work specified.

1. Service During installation
   1. Number of man-days at the site 3
   2. This includes certification that the equipment has been properly installed and is ready for operation.

2. Operation and Maintenance Training
   1. Number of man-days at the site 2

3. Assistance with functional testing, commissioning and acceptance testing (reference Appendix XX)
   1. Number of man-days at the site 3

1.06 ENVIRONMENTAL CONDITIONS

A. Environmental Requirements: Comply with the environmental considerations described in Section 11000. Pre-dewatered cake bin system equipment will be installed at the cake bin level of the Solids Processing Building.

1. Cake bins shall receive dewatered sludge from pre-dewatering centrifuges located on the upper level of the Solids Processing Building via rectangular chutes and a conveyor system.

2. Any bin inlet chute surface in contact with the dewatered sludge cake shall be inclined at an angle greater than or equal to 70 degrees from the horizontal.

3. Live bottom dischargers shall be configured to deliver dewatered sludge directly into the suction inlets of sludge cake transfer pumps (THP Feed Pumps) by means of flanged flexible connecting chutes with THP feed pump isolation motor operated slide gates.

B. Utilities: The pre-dewatered cake bin system equipment shall be connected to the following services:

1. Sludge Cake Feed: Feed of dewatered sludge cake from centrifuges via chutes and a screw conveyor system at a rate up to 1,200 lbs ds/hr (15% to 22% range) per centrifuge (up to 3,600 lbs ds/hr per bin).
   1. Wet cake density can range from 55 lbs/cubic foot (cf) to 75 lbs/cf.
   2. Sludge cake angle of repose approximately 45 degrees (±3 degrees) from horizontal.

2. Sludge Cake Transfer: Gravity discharge (two per bin, one duty, one standby) to suction inlet of progressive cavity type, positive displacement pump (THP feed pump) with capacity to transfer wet sludge cake at the rate to maintain positive pressure with the same physical characteristics as the sludge cake feed.

3. Plant Water: Filtered plant effluent as specified in Specification Section 11351.

Comment [TJN4]: This range will be more precise after selection of THP System Supplier

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4. Foul Air Exhaust: Duct system maintained at minimum ½-inch negative static pressure to draw foul air to odor control treatment system.

5. Power Wiring: 480-volt, 3-phase, 60-hertz service with capacity to accommodate [TBD] KVA total connected load from live bottom sludge storage system equipment.

6. PCS: As specified in Division 13, with capacity to accept all inputs, perform monitoring and control functions, and provide all outputs required by live bottom sludge storage system equipment.

1.07 MANUFACTURER'S WARRANTY

A. The conveyors and bins (bins and live bottoms) shall be warranted for 7 years to be free of defects in material and workmanship. Warranty shall be prorated over the last 5 years.

B. Provide a 1-year warranty for associated mechanical and electrical equipment (bearings, motors, gear boxes, couplings, lubricating assemblies, load cells, loading panel, etc.), with warranty period to start upon satisfactory installation, start-up, and acceptance by the Owner.

C. Refer to Section 01740.

1.08 MAINTENANCE

A. Lubricants and Fluids

1. Furnish a one-year supply of lubricants and fluids for all equipment (including motors), including break-in lubricants, special lubricants and the required containers, hand pumps or other devices necessary to store and/or apply the lubricants.

B. Spare Parts

1. Furnish spare parts for each cake bin conveyor pair as follows:
   a. One outboard bearing for each size.
   b. Spare lube assembly.
   c. Two gaskets of each size.
   d. Four shaft seals.
   e. Eight shaft seal packing sets for stuffing box.

2. Furnish the following additional spare parts for each cake storage bin.
   a. One spare load cell and mounting hardware.
   b. Two spare live bottom discharger screws complete with coupling shafts and bearings.

C. Furnish one complete set of all special tools required for normal operation and maintenance.

D. Package spare parts and special tools for storage with labels indicating the contents of each package. Spare parts and special tools shall be packaged and delivered to the Owner in accordance with Section 01600.

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PART 2 PRODUCTS

2.01 GENERAL

A. Design: Provide a system of two live bottom cake bins including all nozzles, hatches, ladders, supports, conveyors, drives, instruments, and accessories to receive, store and transfer dewatered sludge cake from the bin to the THP feed pumps to comply with the following requirements:

1. Number of Bins: Two.

2. Total height of each bin, including support structure: 20 feet maximum.

3. Total width of each bin, including stiffeners: 12 feet maximum.

4. Storage Capacity per Bin: 60 cubic yards (CY) (minimum) of dewatered sludge cake allowing for 45-degree angle of repose and minimum 15-inch clearance between bin cover and sludge cone at inlet. Total bin volume shall be 72 CY (minimum).

5. Sludge Cake Inlet Chute: Provide flanged connections for four (4) chutes at each bin roof (cover), sized and located as specified in Paragraph 1.01A.

6. Vent Connections: Foul and fresh air connections shall be sized as specified in Paragraph 1.01A.

7. Bin Bottom Segment: Slope bin sides in bottom segment to direct sludge cake to live bottom discharger. Slope bin bottom side walls in contact with the dewatered sludge cake at an angle greater than or equal to 70 degrees from the horizontal.

8. Live Bottom Discharger: Provide either:
    1. Four live bottom conveyor screws per bin driven by two VFD driven gearmotors and spur gears.
    2. Four live bottom conveyor screws per bin driven by four VFD driven gearmotors.

9. The live bottom discharger shall be designed to transfer cake from the bottom of each bin to a conveyor discharge chute. The discharge chute shall be designed to convey cake from the feeder screw(s) to either THP feed pump. The discharge chutes shall have gated outlets for sludge cake transfer pump inlets based on the capacity stated in Paragraph 1.03B of this specification.

10. Sludge Cake Transfer Pumps: Allow for two (2) pumps (1 duty and 1 stand-by) to receive dewatered sludge cake from each bin.

11. Seismic: Design bins in accordance with IBC Chapter 16 for seismic category D.

B. Configuration: Design and fabricate each cake bin as a functional unit divided into multiple segments if necessary to accommodate shipping restrictions, building access restrictions, or prevent damage to individual components. Provide lifting lugs and grounding lugs for each major segment with match marks as required to facilitate proper alignment and field assembly.

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1. Provide access with hatches, manholes, ladders and platforms as required to service and maintain all components of the fully assembled system.

2. Provide railings, cages, guards, chains, signs, and other features required to comply with OSHA 1910.

3. Provide flanged ends for bin nozzle interfaces with external piping, chutes, and ductwork unless otherwise indicated. Provide flexible connections as required to isolate bins from vibration associated with external building systems and rotating equipment.

4. Wire electrical power, monitoring and control components to terminal strips in panel enclosures on each bin assembly for connection to external systems.

2.02 MATERIALS

A. Fabricate and assemble live cake bin system equipment using materials as indicated in the following table.

Component	Material
Screw flights	ASTM A276 stainless steel, Type 316
Torque tubes	ASTM A554 stainless steel, Type 316
Screw troughs and covers	ASTM A480 stainless steel, Type 316
Bin shell	ASTM A480 stainless steel, Type 316L
Drive and non-drive shafts	ASTM A322 steel, UNS 41400
Structural supports and bin reinforcement (external, non-wetted)	ASTM A36, with high-performance coating per Specification Section 09902
Hardware	ASTM A276 stainless steel, Type 316L
Bolts, nuts, and other threaded components	ASTM A276 stainless steel, Type 316L
Gaskets	Neoprene, 50 durometer, 3/32" for bolted covers and 1/8" for trough section flanges
Trough Cover Gaskets	3/8" Friction fit and bubble face
Gate frames, blades, and other components	ASTM A276 stainless steel, Type 316

2.03 CAKE BINS

A. Fabricate each cake bin as a watertight, welded, stainless steel vessel with flat top and hopper bottom converging on the live bottom discharger. Construct bin shell with ¼-inch minimum plate thickness. Design bin stiffening members to limit deflection of any bin shell surface to 1/270th of span. Design each bin to rest on load cells, located on bin support structure.

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1. Provide gasketed, flanged connections for all accessories shipped loose for field assembly and any bin segments not joined by field welds.

2. Do not include any flanged connections within the sloped portion of the bin. Provide a means to remove the live bottom discharger augers from the bin by way of the drive or non-drive end within the dimensional limits shown on the Drawings.

3. Design the top of each bin to support live loads of up to 100 pounds/square foot, in addition to any loads from installed equipment.

4. Design all openings in bin top to be airtight when closed. Design all openings in bin side shell and hopper bottom to be watertight when closed.

5. Provide vent exhaust connection to foul air ductwork and vent inlet connection to building exterior for each bin.

B. Provide continuous seal welds in conformance with AWS D1.1 at all welded joints. Skip welds will not be permitted. After welding, clean stainless steel components using a solvent free of chlorides. Remove embedded iron from stainless steel by pickling with nitric or hydrofluoric acid. Grind welds smooth and to a uniform finish. Comply with Section IX of the ASME Boiler and Pressure Vessel Code for welder qualifications.

C. Externally mount supplementary reinforcing members such as angles, beams, stiffeners, and gussets to provide a smooth interior surface. No internally mounted structural elements will be allowed.

D. Provide a hinged, gasketed, lockable hatch for inspection and access on each bin top with a minimum 3-foot by 3-foot clear opening. Also provide mounting brackets and openings for level sensor, high level switch, and sludge chutes in each bin top.

E. Provide a 3-foot diameter, hinged, gasketed, single flanged, bolted manway near the base of the bin straight side wall with flush interior surface for access to the bin interior.

F. The bin shall include provisions to support conduit, junction boxes, and panels associated with power and control wiring for instrumentation connections.

G. The bin interior is rated Class I, Group D, Division 1 (CID1) Hazardous Locations. Instruments within the bins shall be provided with NEMA 7 enclosures rated for such locations, or shall be provided with intrinsically safe circuits.

2.04 LIVE BOTTOM DISCHARGERS

A. Each live bottom shall be equipped with two twin screw auger/conveyor feeders in the bottom of the bin. The screws shall be specifically designed and configured for sludge cake. The screws shall be designed to prevent bridging and to allow efficient flow of sludge through the bin openings and into the THP feed pumps at the required range of flow rates. The screws shall be designed with a 2.0 safety factor to turn at maximum speed without overloading the drivers when the bin is at the high level set point and maximum capacity is being delivered. The screw

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components shall be designed to withstand the full load of the drive motor without suffering permanent damage.

B. Size conveyors for capacity greater than or equal to the THP feed pump capacity and as -stated in Paragraph 1.03B of this Specification with maximum shaft speed of 12 rpm and filling efficiency of 80 - 100 percent, and drive units for 150 percent full load conditions. Live bottom conveyor transport efficiency shall be 95 percent. Provide deflectors above the screws in the live bottoms to prevent excess cake entry into the screw augers.

Comment [TJN5]: THP feed pump capacity shall be determined by the THP System Supplier in order to meet the specified loading rates listed in Attachment C of the RFP.

C. The pitch shall be constant or variable as determined by the bin manufacturer to achieve proper performance in this application. The twin screws shall have flights designed to promote even, positive delivery of material. Screw flights shall be a minimum 1/4 inch thick and shall be continuously seal welded on both sides to torque tubes of sufficient strength and section to withstand all radial and thrust loads imposed by the system under the worst condition of load.

D. Each live bottom screw shall be supported at the drive and non-drive end with grease lubricated outboard bearings. Bearings shall be designed to resist all radial and thrust forces under the worst conditions of load and maximum screw speed with a 2.0 factor of safety. No intermediate bearings will be allowed.

E. Each live bottom screw pair shall have discharge opening located at the feeder bottom (total of two openings for twin live bottom conveyor assembly). Flanged connections for mounting electric operated slide gates shall be provided. Discharge opening shall be located at the opposite end of the live bottom from the screw motors. Flow control devices shall be centered above each discharge opening.

1. Drive and Non-Drive Shafts: connect to the screw conveyor torque tube and size to transmit anticipated operating loads with a minimum safety factor of 2.0. Provide shafts with flanged ends and mating bolt holes to match the torque tube flanged end plate incorporating a minimum 5/32-inch register between the mating of the flanges. The shaft flange shall be integral with the shaft as either a single piece forging or a welded shaft-to-flange construction.

2. Packing Gland Seals: provide where shafts project through trough end plate. Packing gland shall have 1/2-inch by 1/2-inch nominal Teflon impregnated packing rings. Provide adjustment provisions to tighten the packing onto the shaft. Provide grease fitting with a lantern ring set in the middle of the packing rings, with not less than two rings of packing on the sludge side of the lantern ring. Bolt seal housing to the trough end plate. Each packing gland seal assembly shall have minimum of four packing rings and a grease lantern ring.

2.05 BEARINGS

A. Bearings shall be spherical roller bearings mounted in cast iron pillow block bearing housings. Bearings shall have a minimum ABMA L-10 rating of 50,000 hours. Fit each bearing housing with a grease nipple and escape release provisions.

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B. Mount bearings outboard of the seal housing with sufficient clearance to permit removal of seal housing bolts, covers, and repacking without having to remove the bearing housing or bearing from the housing. Thrust-carrying bearings shall be fixed-location, with spherical roller bearing mounted on the drive shaft, complete with bearing recess shoulder. Non-thrust bearings shall be non-locating, free-floating assemblies. Where no power is transmitted to the shaft, non-thrust bearings may be mounted with a tapered bore, plus ring adaptor, on a plain diameter shaft. Mounting of pillow block bearings to the drive and non-drive shaft assemblies, and all components mounted to or upon which the bearing is mounted, shall conform to the requirements of the bearing manufacturer for the loading and design conditions of the service.

2.06 DRIVE UNIT

A. Each screw auger drive shall consist of an integral gear reducer/motor drive or speed reducer mounted to the trough or bin end plate with stainless steel mounting stool.

B. The screw auger drives shall be either of the following.

1. Provide a single gearmotor and spur gear arrangement such that a single gearmotor drives a pair of screw augers.

2. Provide an independent drive such that each screw auger is driven by a single gearmotor.

C. Motors conforming to Section 16150 shall be sized for requirements of the driven loads with consideration given to all drive train component efficiencies and system overload requirements. Motors shall be high efficiency, inverter duty rated for use with VFD's.

D. Variable speed drives will be provided by the bin manufacturer in accordance with Division 16.

2.07 DISCHARGE CHUTES (LIVE BOTTOM CONVEYOR DISCHARGE CHUTES WITH THP FEED PUMP ISOLATION GATES)

A. The live bottom conveyor discharge chute (one per bin) shall include the following.

1. Live bottom conveyor discharge chute that connects the live bottom discharge flange to the THP feed pumps inlets.

2. Pump isolation motor operated slide gates (two per bin) mounted on the discharge chute.

3. A minimum ¼ inch thick Type 316 stainless steel discharge chute shall be provided for each bin unit. Each chute shall have dimensions, connections and general shape as indicated on the Drawings and as required by the conveyor discharge and the THP feed pump inlet. Each chute shall be provided with a flange suitable for bolting to a flexible discharge connector, provided by the cake bin supplier. Hinged, quick-opening inspection openings with gasketed watertight covers using DE-STA-CO type latches shall be provided on each chute in accessible locations. Openings shall be watertight. The juncture of all joints in plates shall be continuously seal welded inside and out so that the chute is watertight. Stiffeners shall be provided as required to limit stresses and deformation in the plates during shipping, installation and operation. The chutes shall be supported from the floor and not the THP feed pump

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~~3.~~4. . All hardware shall be Type 316 stainless steel. Provide grab sample ports with quick disconnect cap and chain.

B. Provide two isolation gates off of the live bottom discharge chutes.

1. The isolation gates shall be supplied with a motor actuator suitable for connection to 480 VAC, 3 phase power supply.

2. Diverter gates and associated hardware shall be Type 316L stainless steel and shall be flanged into the sludge cake chute. Provide suitable support for the gates and actuators. The gate shaft and disc shall be of Type 316L stainless steel. The gate shall have a minimum thickness of ¼-in and have stiffeners to prevent deformation and withstand seating pressures.

3. The gate shall be manually/automatically operated, timer controlled with controls located at the local control panel. Adjustment of time setting shall be provided.

4. A resilient rubber seal shall be provided around the gate opening to form a watertight seal when the gate is closed. The seal shall be replaceable.

5. The slide gate width shall match the width of the solids discharge chute.

6. The spray pipe shall be replaced without removing the chute. The spray nozzles shall be Type 316 stainless steel and mounted to a Type 316 stainless steel spray pipe manifold. Spray nozzles are to be Type HU by Spraying Systems Co., Wheaton, IL, or equal.

7. Each gate shall include the following.
   a. Welded construction per AWS standards.
   b. Gate blade supported on 1-1/4-inch Type 316 stainless steel rollers, located out of the material flow.
   c. Rollers shall include bronze bushings which require no lubrication.
   d. Gate blade leading edge beveled to facilitate its travel through material being handled.
   e. All product contact surfaces lined with 1/4-inch thick, Type 316 stainless steel.
   f. Drain/trough shall be sloped to catch and retain free water.
   g. Drain line connection: 2 1/2" diameter spigot, suitable for approved coupling connection.
   h. Provide flushing water connection: 1/2" diameter in the drain trough. Spigot with manual valve, suitable for approved coupling connection.
   i. Provide NEMA 4X lockable power disconnect.
   j. Provide actuator with NEMA 4X enclosure.
   k. Open-close time shall be 15 seconds.
   l. Limit switches for CLOSED and OPENED positions.
   m. Control and monitored by centrifuge control panel.
   n. Provide remote mounted control station, NEMA 4X located near the gate and actuator with:
      1) LOCAL-OFF-REMOTE selector switch.
      2) OPEN and CLOSE pushbuttons.
      3) OPENED and CLOSED pilot lights.

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4) Gate wiping seals made of UHMWPE. Seals contact the top of the gate blade along the perimeter of the throat opening. Seals shall be retained by a bolted steel bar which forms the inlet throat lining of the slide gate.
5) The gate shall include a directional control valve, 2-way, 1-coil, 2-position, with spring return, and NEMA 4X enclosure mounted to the gate frame and housed to the cylinder.
6) The gate shall include two pairs of limit switches for each operating cylinder, SPDT, each with NEMA 4X enclosure, mounted to the gate retract frame for remote open/close position indication.
7) Retract blade area shall have expanded metal safety guards above and below the blade.

2.08 LOAD CELLS

A. Each cake bin shall be supported by a sufficient number of load cells (minimum four load cells, to be verified by bin manufacturer) to accurately determine loaded weight of the bin and subtract bin tare weight, allowing continuous calculation of weight of contents. Load cells shall be as specified below.

1. Construction: Load cells shall use strain gauge technology to continually measure the weight of material in cake bin with an accuracy of 0.1 percent of span or better, with a repeatability of 0.01 percent. Strain gauges shall be mounted as a load cell, configured to perform as a rocker pin.

2. Physical: Load cells shall have a stainless steel canister, hermetically sealed with a minimum NEMA 6P/IP 68 rating. Cells shall be bonded, temperature compensated, and protected against corrosive atmospheric conditions, abrasives, and buildup of dirt. Temperature range shall be 0 to 100 degrees Fahrenheit. Provide adapter plate and mounting and adjustment hardware. Cells shall have integral twisted shielded cable of sufficient length for installation as shown on the Drawings.

3. Load cells shall be installed as structural members supporting the cake bins. Cells shall be fabricated of high overload capacity stainless steel; mounting hardware and assembly bolts of Type 316 stainless steel shall be provided.

4. Power supply: Load cells shall be powered from the remote transmitter.

5. Rating: Load cells shall have a minimum ultimate overload rating of 400 percent of rated capacity, and a minimum safe overload rating of 200 percent of rated capacity.

6. Certification: Load cells shall be certified by National Type Evaluation Program (NTEP) of the National Conference on Weights and Measures (NCWM) and meet specifications as set forth in NIST Handbook 44 for Class III L, 10,000 devices.

B. The load cells shall be connected to a remote transmitter unit.

1. Type: Transmitter shall be microprocessor based and capable of receiving signals from minimum four strain gauge type load cells.

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2. Resolution: The transmitter include A/D converter of minimum 18 bit resolution.

3. Response time: Less than 1 second.

4. Output: Isolated 4-20 mA output current for the total weight measured by all the load cells.

5. Display: Backlit alphanumeric LCD type. Weight indication to be selectable in pounds or kilograms.

6. Keypad: Provide an integral keypad to program the transmitter unit.

7. Power Requirements: 115 VAC/60 Hz.

8. Physical: NEMA 4X type enclosure. Suitable for surface mounting.

C. Manufacturer: Kistler Morse, Load Cell model LD3 and Transmitter model SVS-2000

2.09 ULTRASONIC LEVEL SENSORS

A. Two ultrasonic level sensors shall be mounted on the top of each cake bin. Each sensor shall be equipped with adjustable flange to adjust the direction of the sensor. The sensors shall be provided by the Div. 13 Systems Integrator.

B. Provide suitable sensor mounting flanges installed on top of the bin to install the level sensor.

2.10 HIGH LEVEL SWITCHES

A. Rotating blade type level switches shall be mounted on the top/side of each cake bin where shown on the Drawings. Level switches shall be as follows:

1. Paddle actuated level switch shall consist of a paddle, torque shaft and a lever actuated switch. The switch assembly shall contain a 120 VAC, 1 RPM synchronous motor that shall turn the paddle in the absence of bulk material, when contacted by the bulk material, the paddle shall stop, causing the motor to turn, actuating relay contacts.

2. A time delay feature shall be included to prevent spurious alarms. The switch assembly shall be enclosed in a NEMA 4X housing unless otherwise specified. Process contacting components and paddle shall be Type 316 stainless steel unless otherwise specified. Minimum temperature rating shall be 180 degrees F. Paddles of various sizes shall be available to provide the switch point range specified.

3. Contact output shall be 2 SPDT switches for alarm, and shall be normally closed, opening to initiate the alarm. Contacts monitored by PCS shall be rated for a minimum of 5 amperes at 120 VAC. Contacts monitored by electromagnetic devices such as mechanical relays shall be rated NEMA ICS 2, designation B200.

4. Double barriers shall be provided between switch elements and process fluids so that failure of one barrier will not permit process fluids into electrical enclosures.

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5. Contacts located in Class I Division 1 areas shall be provided with NEMA 7 enclosures or wired to intrinsically safe circuits.

6. Level switch shall be a Roto-Bin-Dicator by Bindicator.

2.11 FINISHING REQUIREMENTS

A. General: All fabricated non-stainless steel or ferrous metal surfaces shall be fully prepared with shop applied prime and field-applied final coats of a high solids epoxy system. Stainless steel surfaces shall be insulated from direct contact with ferrous metal.

B. Screw Conveyors:

1. Screw:
    1. Weld: Weld spatter and slag removed, rough grind welds to remove heavy weld ripple or unusual roughness (equivalent to a 40-50 grit finish) pits and crevices permissible (CEMA II).
    2. Flight Surface: Mill finish 2B (gauge), 2D (plate), other as purchased, no grinding on steel surfaces, chemical clean.
    3. Pipe: Mill finish 2D or other as purchased. No grinding on steel surfaces, chemical clean.

2. Housing:
    1. Weld: Interior and exterior, weld spatter and slag removed, rough grind welds to remove heavy weld ripple or unusual roughness (equivalent to a 40-50 grit finish) pits and crevices permissible (CEMA II).
    2. Housing Surface: Interior and exterior, mill finish 2B (gauge), 2D (plate), other as purchased, no grinding on steel surfaces, chemical clean.

C. No painting is required on stainless steel surfaces.

D. All housings for bearings, seals, drive components and other purchased components will be furnished with manufacturer's standard paint system. Safety guards shall be painted Safety Yellow.

2.12 EMERGENCY STOP DEVICES

A. Provide an emergency stop pull cord around the live bottom dischargers of each bin. Provide a minimum of two switches, both of which shall be actuated when the pull cord is pulled at any point along its length. Provide NEMA 4X enclosures for pull cord switches. Switches shall be provided with sufficient normally closed contacts to allow immediate and direct shutdown of all cake bin drives.

B. Provide an emergency stop pushbutton at the discharge gate operator to shut down the bin drives if depressed. Pushbutton shall be provided with sufficient quantity of contacts to allow immediate and direct shutdown of all cake bin drives.

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PART 3 EXECUTION

3.01 INSTALLATION

A. Align, connect, and install equipment at the locations specified and in accordance with the manufacturer's written recommendations. Install and test under the direction of factory-trained personnel.

3.02 FIELD TESTING (FUNCTION TESTING, COMMISSIONING AND ACCEPTANCE TESTING, REFERENCE APPENDIX 7 FOR FURTHER DETAILED REQUIEMENTS)

A. After completion of installation, the equipment shall be completely field tested to demonstrate compliance with the performance requirements as specified.

B. Testing procedures shall duplicate as nearly as possible the conditions of operation and shall be selected to demonstrate that the equipment is operational and free from damage. Each control device, item or mechanical, electrical, and instrumentation equipment, and control circuits shall be considered in the testing procedures to demonstrate that the equipment has been properly serviced, aligned, connected, calibrated, and adjusted prior to operation.

C. Hydraulic Test:

1. Hydraulically test bins by completely filling each bin with water to within 6 inches of top. Bottom slide gates shall be blanked off with full face neoprene gaskets during the water test. The maximum allowable leakage rate shall be 0.25 percent of bin volume in 24 hours, with zero leakage from welded connections. Following successful testing, the bins shall be emptied and the bottom slide gate gasketed blanking plate removed.

2. Test discharge gates after successful completion of bin hydraulic testing. Discharge gate shall be capable of withstanding the design head (bin filled to the design sludge level) without leakage exceeding 0.25 percent of bin volume in one hour.

END OF SECTION

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SECTION 11315A
PROGRESSING CAVITY PUMPS (For THP Pre-Selection Only)

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Positive displacement progressing cavity pumps for the Thermal Hydrolysis System, complete with electric motors, variable frequency drives, and all specified appurtenances, mounted on a common baseplate.

1.02 QUALITY ASSURANCE

A. Reference Standards:

1. AGMA 6010-E: Spur, Helical, Herringbone, and Bevel Enclosed Drives.

2. AGMA 6019-E: Gear Motors Using Spur, Helical, Herringbone, Straight Bevel, or Spiral Bevel Gears.

3. American national Standard Institute (ANSI)

4. American Bearing Manufacturers Association (ABMA)

5. National Electrical Manufacturers Asscociation (NEMA)

6. Occupational Safety and Health Administration (OSHA)

7. Where reference is made to one of the above standards, the revision in effect at the time of manufacture shall apply

B. Other technical specifications specifically related to this specification include:

1. Section 11000 - General Requirements for Equipment

2. Section 13330 - Control Panel Enclosures and Panel Equipment

3. Section 16191A – Miscellaneous Equipment (For THP Pre-Selection Only)

4. Section 16150 - Motors

5. Section 16370 –Variable Frequency Drives

C. Services of Manufacturer's Representative

1. Provide services of a manufacturer's representative in accordance with Section 01730. Representative shall be a factory trained and certified service technician who has complete knowledge of proper operation and maintenance of the screenings equipment.

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2. The Progressing Cavity Pump Supplier shall provide qualified representatives to the site, summarized herein. The supplier shall indicate, in his quote to the General Contractor, the number of on-site man-days and the number of trips to the worksite necessary for the supplier to perform the work specified.
   a. Service During installation
      1) Number of man-days at the site 3
      2) This includes certification that the equipment has been properly installed and is ready for operation.
   b. Operation and Maintenance Training
      1) Number of man-days at the site 2
   c. Assistance with functional testing, commissioning and acceptance testing (reference Appendix XX)
      1) Number of man-days at the site 3

3. If there are difficulties in operation of the equipment due to the manufacturer's design or fabrication, additional service shall be provided at no additional cost to Owner.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. All pumps moving liquid sludge/sludge slurry shall be progressing cavity pumps. Within the THP system, this includes, but is not limited to, THP feed pumps, Digester feed pumps, and Recirculation pumps, if required.

2. The equipment including the drive train, shall be designed for operation at variable speed, and shall be in-line configuration. Motor and gearing shall be designed to transmit 150 percent of the maximum torque required to be transmitted under the full range of operating conditions.

3. The pumps, along with associated drive appurtenances, shall be mounted on common fabricated steel baseplates. Each baseplate shall contain and direct excess flushing water to a single outlet.

4. Progressing cavity pumps for liquid sludge/sludge slurry service shall have the following operating characteristics:
   a. Maximum pump speed (rpm): 200.
   b. Motor/drive: Constant torque type, adjustable frequency.
   c. Required Redundancy as listed in Specification 11351.

B. Pump design Criteria:

1. Progressing Cavity pumps for the THP system shall be by Moyno/Mono or Seepex.

2. Pump Service: __
   a. Number of Pumps __
   b. Flow-rate (gpm) __
   c. Sludge Percent Dry Solids (%) __

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d. Design Discharge Pressure (psig) ___
e. Design Sludge Temperature (deg F) ___
f. Maximum Pump Speed (rpm) ___
g. Motor Horsepower (HP) ___
h. Maximum Motor Speed (rpm) ___
i. Pump Make and Model ___-__

3. Pump Service: ___
a. Number of Pumps ___
b. Flow-rate (gpm) ___
c. Sludge Percent Dry Solids (%) ___
d. Design Discharge Pressure (psig) ___
e. Design Sludge Temperature (deg F) ___
f. Maximum Pump Speed (rpm) ___
g. Motor Horsepower (HP) ___
h. Maximum Motor Speed (rpm) ___
i. Pump Make and Model ___-__

4. Pump Service: ___
a. Number of Pumps ___
b. Flow-rate (gpm) ___
c. Sludge Percent Dry Solids (%) ___
d. Design Discharge Pressure (psig) ___
e. Design Sludge Temperature (deg F) ___
f. Maximum Pump Speed (rpm) ___
g. Motor Horsepower (HP) ___
h. Maximum Motor Speed (rpm) ___
i. Pump Make and Model ___-__

Comment [TJN1]: To be completed once THP System Supplier is selected.

C. Utilities: Services available for connection to sludge pumping equipment include plant reuse water piping, electrical power wiring, and the PCS.

1. Plant Reuse Water: Characteristics of plant reuse water available for use within the THP system is listed in Specification 11351.

2. Power Wiring: 480-volt, 3-phase, 60-Hertz service.

3. PCS: Rockwell Automation Allen Bradley 1769 CompactLogix System with capacity to accept all inputs, perform monitoring and control functions, and provide all outputs required for the pumping system VFDs.

1.04 SUBMITTALS

A. Product Data: Manufacturer sales brochures, catalog cuts, data sheets, schematics, wiring diagrams, installation instructions, and maintenance instructions for standard components such as pumps, gear reducers, seals, and couplings.

B. Submit the following information:

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1. Certified shop and fabrication drawing showing all details of construction, dimensions and anchor bolt locations.

2. Descriptive literature, bulletins and/or catalogs of the equipment.

3. Specific information on the stator bond technology and how it will be designed to handle the high temperatures experienced in hydrolyzed sludge applications.

4. A reference list identifying where the proposed pump, with the stator bond technology, has been installed for hydrolyzed sludge applications.

5. Data on the characteristics and performance of the pump. The data shall include guaranteed performance curves, based on actual shop tests of like pumping units, which shall show that the pumps meet the specified requirements of head, capacity and horsepower.

6. Complete data on motors and power factor correction capacitors conforming to the requirements of Section 16150.

7. Complete master wiring diagrams of local control stations, elementary or control schematics, including coordination with other electrical control devices.

8. The total weight of the equipment, including weights of the larger components.

9. A complete bill of materials and materials of construction for all equipment components.

10. A list of manufacture's recommended spare parts.

11. Mill certificates confirming hardness of rotor and stators as specified

C. Operations and Maintenance Data (in accordance with Specification 01730)

1. Complete operation and maintenance data shall be furnished for all equipment included under this Section, as specified in Specification 01730. The maintenance instructions shall include maintenance plan for the equipment, troubleshooting data and full preventative maintenance schedules, recommended cleaning instructions, procedures and safety precautions for equipment and complete spare parts lists with ordering information. Standard operating and maintenance instructions typically provided by equipment manufacturers shall not be accepted as fulfilling this requirement.

2. Servicing Plan including warehousing and distribution plan, stocking strategy, spare parts inventory and supply plan, QA/QC procedures and qualifications/experience of factory trained service representatives to be available for this job. Such a plan will include locations of warehouses, service shops, emergency response time and other relevant information.

D. Warranties

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1. Submit warranties for work under this Section and special warranties listed below.

2. Letter from equipment manufacturer confirming proper installation, proper commissioning, performance limits, covered components and warranty effective dates.

3. Submit copy of the rotor warrantee agreement as referenced in Section 2.3.B of this specification.

1.05 DELIVERY, STORAGE AND HANDLING

A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation.

B. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

C. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

D. 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.

E. Each box or package shall be properly marked to show its net weight in addition to its contents.

F. Manufacturer shall assume responsibility for packaging to prevent normal transit and handling damage.

G. Finished surfaces of all exposed openings shall be protected by wooden blanks, strongly built and securely bolted thereto or by other approved means.

1.06 MAINTENANCE

A. Tools and Spare Parts

1. Provide special tools, if required for normal operation and maintenance, with the equipment in accordance with the provisions of Section 01730.

PART 2 PRODUCTS

2.01 GENERAL

A. Type: The pumping units shall be of the self-priming, positive displacement, progressing cavity type specifically designed for pumping wastewater treatment sludges in liquid or slurry form containing organic solids and small inorganic particles.

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B. Manufacturers: Only Moyno/Mono and Seepex models with appropriate stator bond technology will be accepted for pumps associated with the THP system.

2.02 MATERIALS

A. Material characteristics specified herein establish the minimum acceptance criteria for the purposes of durability, strength, and resistance to erosion and corrosion. The pump manufacturer shall determine if the materials proposed are capable to operate continuously at the hydrolyzed sludge operating temperatures.

Component	Material
Rotor	High-carbon, high-chrome tool steel, chrome plated with minimum Brinell hardness of 550 or 1 percent aluminum nitriding steel hardened in excess of Rockwell 70 C.
Stator	Buna-N synthetic rubber with a minimum shore durometer hardness of 60 bonded to a steel tube.
Pump body	Cast iron
Shaft sleeve	Stainless steel, Type 316 (for pumps with hollow drive shafts)

2.03 EQUIPMENT

A. Rotor and Stators: Each pump shall be two-stage design employing a convoluted rotor operating in a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the pump's inlet to discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

B. Rotor Drive Train: The rotor drive train shall be unconditionally warranted for 3 years from acceptance and shall consist of one of the following types:

1. Each pump rotor shall be driven through a connecting rod which shall be connected to the rotor and input shaft through precision machined crowned gear type joints. The balls and sockets shall be machined from chrome alloy tool steel and shall be designed to withstand shock and thrust reversal. Each gear joint shall be protected against the entrance of dirt, sludge, and other foreign objects by a sealed steel shell. Gear joint shall be positively secured to the connecting rod to ensure against failure when the pump is in operation. The connection rod shall maintain shaft angularity of less than 1.5 degrees.

C. Pump Casing: The pump casing shall be provided with a cleanout opening on each side of inlet fitting. Cleanout opening shall be located immediately opposite the rotor head gear joint to provide access for maintenance. A 125-pound flanged connection shall be provided at both the inlet and discharge ports. The suction shall be provided with a minimum 1/2-inch tap to permit installation of a water lubrication system.

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D. Seals and Bearings: Each pump shall be provided with grease lubricated thrust and radial bearings designed for all loads imposed by the specified service. The pump shall be equipped with a split mechanical seal that is capable of continuous operation without flushing water. Under normal operation water flush is supplied to the seal. The stuffing box housing shall be drilled and tapped for water flush connections. The shaft, where inside the stuffing box, shall be fitted with a replaceable sleeve. Supply stuffing box and seal in conformance with Specification 11000 except as modified herein.

E. Anti-reversal Holdback: Each pump shall be equipped with a differential friction- type holdback designed to prevent reversal of flow when the pump is not in operation. Unless otherwise specified the holdback shall act directly on the pump shaft and shall be equipped with a housing to protect the unit against the entrance of dust, dirt, and moisture. Anti-reversal holdbacks shall be adequately sized for the specified service. Shaft extensions shall be provided where required.

1. Where a gear reducer is direct connected, the holdback shall be incorporated into the gearbox.

2. In lieu of friction type holdbacks, each pump may be provided with electric brake motors to prevent anti-rotation of the pump. Brake shall release when motor starts and shall engage when motor shuts down or on power failure.

F. Motor and Drive Unit:

1. Pumps shall be motor driven provided in an in-line configuration. Motors shall be inverter duty with TEFC enclosures as specified in Specification 16150, with a 120 volt space heater wired to the variable frequency drive (VFD).

2. Variable speed drives shall be rated as Constant Torque type as specified in Division16. Variable speed drives speed range shall be selected to cover operational condition range. VFD's shall be provided by others.

3. Gear motors or gear reducers, designed in accordance with AGMA 6019-E (Class II) or AGMA 6010-E (Service Factor 1.25), shall be provided where greater speed reduction is specified.

4. The reduction ratio is required to operate the pump at its maximum operating speed when the motor is operating at its nominal rated full speed.

5. Motor shall be provided with winding temperature detectors. Detectors shall be factory installed, embedded, bi-metallic switch type with leads terminating in the conduit box. Detector shall protect the motor against overheating caused by single-phasing, overload, high ambient temperature, abnormal voltage, locked rotor or ventilation failure and shall be coordinated with the VFD shut down circuit. Switch shall have normally closed contacts, and not less than three detectors shall be furnished with each motor.

G. Base: Pump base and support shall be rigidly mounted. Pumps and drive assemblies shall be supported on common base pads or pedestals, as specified.

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2.04 VARIABLE FREQUENCY DRIVE

A. The THP System Supplier shall supply the variable frequency drives required to operate the progressing cavity pumps as specified.

B. Refer to Specification 16370 for general requirements for variable frequency drives.

2.05 CONTROLS

A. General:

1. THP System Supplier shall provide all instruments and controls required to integrate the progressing cavity pumps into the THP system automation.

2. See Division 13 for general requirements of instrumentation associated with the THP system.

B. Equipment:

1. Pressure Transmitters

2. Level Switches

3. Temperature Switches

4. Flow Meters

Comment [TJN2]: More detailed to be provided once THP System Supplier is selected.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 11351 – Thermal Hydrolysis System.

3.02 FIELD TESTING

A. Refer to Section 11351 – Thermal Hydrolysis System.

END OF SECTION

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SECTION 11318
DIGESTER RECIRCULATION CHOPPER 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 two digester recirculating chopper-type pumps as shown on the Drawings and as specified herein.

Comment [TJN1]: To be finalized after selection of THP System Supplier

B. Pumps shall be severe-duty, non-clogging, chopper-type slurry pumping design capable of pumping digested sludge which may contain rags, hair and abrasive grit.

C. Electric motors shall be furnished as part of the work of this section and shall conform to the requirements of Section 16150.

D. Variable frequency drives (VFDs) shall be furnished as part of the work of this section and shall conform to the requirements of Section 16370.

1.02 RELATED WORK

A. Concrete work and installation of anchor bolts is included in Division 3; however, anchor bolts for these units shall be furnished under this section.

B. Field painting is included in Section 09902.

C. Instrumentation is included in Division 13.

D. Digester heat exchangers are included in Section 15754.

E. Mechanical piping, valves, pipe hangers and supports are included in the respective Sections of Division 15.

F. Electrical work is included under Division 16.

1.03 SUBMITTALS

A. Copies of all materials required to establish compliance with these specifications shall be submitted in accordance with the provisions of Section 01300 for shop drawings. Submittals shall include at least the following:

1. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt sizes and locations.

2. Descriptive literature, bulletins and/or catalogs of the equipment.

3. Data on the characteristics and performance of the pumps. Data shall include guaranteed performance curves, based on actual shop tests of duplicate units, which show that they meet the specified requirements for head, capacity, efficiency, allowable NPSH, allowable suction lift and horsepower. Curves shall be submitted on 8-1/2-in by 11-in sheets.

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4. The total weight of the equipment including weight of the single largest item.

5. A complete total bill of materials for all equipment.

6. A list of the manufacturer's recommended spare parts with the manufacturer's current price for each item. Include gaskets, packing, etc., on the list. List bearings by the bearing manufacturer's numbers only.

7. A statement indicating and documenting the life of all ball and roller bearings.

8. Complete data on motors and power factor correction capacitors (if required) in accordance with Section 16150 including results of factory tests.

9. Complete description of surface preparation and shop priming.

10. Factory performance test data as specified in paragraph 1.05.

11. Complete master wiring diagrams, control schematics, including coordination with other electrical control devices.

12. Field test results as specified in PART 3.

13. Manufacturer's warranty.

B. In the event that it is impossible to conform with certain details of the specifications because of different manufacturing techniques, describe completely all nonconforming aspects.

C. Operation and Maintenance Data

1. Operating and maintenance instructions shall be furnished to the Engineer as provided for in Section 01730. The instructions shall be prepared specifically for this installation and shall include all cuts, drawings, equipment lists, descriptions, etc, that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.04 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

B. American Society for Testing Materials (ASTM)

1. ASTM A36 – Specification for carbon structural steel.

2. ASTM A148 – Specification for Steel Castings, High Strength, for Structural Purposes

3. ASTM A532 – Specification for abrasion-resistant cast iron

4. ASTM A536 – Specification for ductile iron castings

5. ASTM A563 – Specification for carbon and alloy steel nuts

C. American Bearing Manufacturers Association (ABMA)

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D. National Electrical Manufacturers Association (NEMA)

E. American Gear Manufacturers Association (AGMA)

F. Occupational Safety and Health Administration (OSHA)

G. 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. Manufacturer/Supplier Qualifications and Requirements

1. The equipment shall be provided, designed and procured by a single supplier who is fully experienced, reputable and qualified in the system and the equipment to be furnished. The equipment shall be designed, constructed and installed in accordance with the best practices and methods. These specifications call attention to certain features, but do not purport to cover all details entering into the design and construction of the equipment.

2. Pumps shall be manufactured in accordance with all applicable standards of the Hydraulic Institute.

3. Pump manufacturer shall furnish pumps, motors, and accessories as complete package to insure proper coordination and compatibility of equipment.

4. The equipment shall be manufactured in accordance with the best practices and methods, and shall operate satisfactorily when installed as shown on the Drawings.

5. The drawings and specifications covered by this Section may be based on the mechanical equipment of a single supplier. Should equipment which differs from this section be offered and determined to be the approved equal of that specified, such equipment will be acceptable only on the basis that any revision in the design and/or construction of the structures, piping, appurtenant equipment, electrical work, etc. required to accommodate such a substitution shall be made at no additional cost to the Owner and be as approved by the Engineer.

6. The manufacturer/supplier supplying this equipment must have at least five installations of the same design, each with a minimum of three years successful operating experience.

7. Pumps, drive units, and motors shall be furnished by the pump manufacturer and be mounted on a common baseplate of cast iron or fabricated steel.

B. Factory Inspection and Tests

1. Motors shall be tested in accordance with Section 16150.

2. VFDs shall be tested in accordance with Section 16370.

3. Provide a certified test curve covering the critical hydraulic variables of each pump including: head, flow and efficiency/power consumption, with test points taken for at least six points along the curve.

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4. Pump casing shall be given a hydrostatic pressure test at a pressure of 1.5 times the maximum shut-off head.

5. Demonstrate that all equipment is capable of continuous operation in satisfactory manner without mechanical or electrical defects or operational difficulties. If necessary, tests shall be repeated until satisfactory results are obtained.

6. All defects revealed by or noted during tests shall be corrected or replaced promptly at no additional compensation.

7. Tests shall be performed in accordance with the latest edition of the Hydraulic Institute Standards.

C. Provide certified copies of all test reports, including the pump hydrostatic test, motor tests, and including documentation of certification/calibration of all test instruments for review by the Engineer. Equipment shall not be shipped until reports have been approved.

1.06 SYSTEM DESCRIPTION

A. All of the equipment included herein is intended to be standard for pumping either a combination of raw and digested sludge or digested sludge alone.

1. Pump Service:
   a. Number of Pumps 2
   b. Flow-rate (gpm) 200
   c. Sludge Percent Dry Solids (%) 6%
   d. Design Discharge Pressure (psig) __
   e. Maximum Pump Speed (rpm) __
   f. Motor Horsepower (HP) __
   g. Maximum Motor Speed (rpm) __

Comment [TJN2]: To be finalized after selection of THP System Supplier

B. Utilities: Services available for connection to sludge pumping equipment include plant reuse water piping, electrical power wiring, and the PCS.

1. Plant Reuse Water: Characteristics of plant reuse water available for use within the THP system is listed in Specification 11351.

2. Power Wiring: 480-volt, 3-phase, 60-Hertz service.

3. PCS: Rockwell Automation Allen Bradley 1769 CompactLogix System with capacity to accept all inputs, perform monitoring and control functions, and provide all outputs required for the pumping system VFDs.

1.07 DELIVERY, STORAGE AND HANDLING

A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the unit and equipment are ready for operation.

B. All equipment and parts must be properly protected against any damage during shipment. Store equipment in accordance with the manufacturer's instruction.

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C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

D. The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted thereto.

E. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

F. 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.

G. No shipment shall be made until approved by the Engineer.

H. Attention is directed to Section 01600.

1.08 MANUFACTURER'S SERVICES

A. Provide the services of a factory trained service engineer, specifically trained on the type and size of the equipment specified. Submit qualifications, in the form of a project-based resume, for approval. The listed man-day requirements are exclusive of travel time, and shall not limit or relieve the THP System Supplier of the obligation to provide sufficient service necessary to place the equipment into fully satisfactory and functioning condition.

1. During Installation: Assist in location of foundation anchors, leveling and alignment, coordination of utility connections (piping, electrical, seal water etc.):

2. Start-Up: Complete review of installation, Provide written certification that the installation is complete and operable in all respects, and that no conditions exist which may affect the warranty. Provide written report, summarizing test procedures, tested and measured variables (flows, pressures, shaft-speed, vibration measurements, alignment check, etc.); instruction on operation and maintenance of the equipment, including start-up, shut-down, troubleshooting, lubrication, maintenance and safety:

3. Service calls, exclusive of warranty work, in the first year of actual operation, and at the Owner's request:

1.09 SPARE PARTS

A. One set of all special tools required for the maintenance, adjustments, and repair of the equipment shall be provided.

B. As a minimum, the following spare parts shall be provided:

1. One mechanical seal.

2. One complete set of gaskets, O-rings, etc. for each pump.

3. One impeller sleeve seal.

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4. Two sets of pump radial and thrust bearings.

5. One cutter bar, impeller, and upper cutter.

6. One set of cutter bar shims.

7. One cutter bar nut.

8. One set of manufacturer's standard overhaul tools.

C. All tools and spare parts shall be furnished in accordance with Section 01100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Established and reputable manufacturers who have experience in the manufacture and installation of the equipment specified are acceptable. Manufacturers included hereinafter, or a submittal as an or equal manufacturer not listed, must comply with the requirements of this specification in its entirety. Acceptable manufacturers of chopper-type pumps include Vaughan Co. and WEMCO.

2.02 MATERIALS AND EQUIPMENT

A. General

1. The equipment covered by this section is intended to be standard pumping equipment of proven ability as manufactured by reputable concerns having long experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods, and shall operate satisfactorily when installed as shown on the Drawings.

2. All parts shall be so designed and proportioned as to have liberal strength and stiffness and to be especially adapted for the work to be done. Ample room and facilities shall be provided for inspection, repairs, and adjustment.

3. Pump bases shall be rigidly and accurately anchored into position and all necessary foundation bolts, plates, nuts and washers shall be furnished by the equipment manufacturer and installed by the Contractor. Anchor bolts, nuts, and washers shall be Type 304 stainless steel.

4. Brass or stainless steel nameplates giving the name of the manufacturer, the rated capacity, head, speed, and any other pertinent data shall be attached to each pump.

5. Brass or stainless steel nameplates giving the name of manufacturer, serial number, model number, horsepower, speed, voltage, amperes, service factor, insulation, and all other pertinent information shall be attached to each motor. The nameplate rating for the motor shall not be exceeded, nor shall the design service factor be reduced when its pump is operating at any point on its characteristic curve.

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6. The manufacturer shall supply all motors and factory mount them on a common base plate with the pumps. Pumps and pump bases shall have suitable provisions to collect leakage and permit it to be drained away.

7. The pumps and motors shall be designed and constructed to avoid the generation of objectionable noise or vibration. The pumps and drives shall conform to the noise limitations specified in Section 01100.

8. The nameplate rating of the motors and drives shall not be exceeded, nor shall the motor design service factor be reduced when its pump is operating at any point on its characteristic curve.

B. Pumps

1. Name: Digester Recirculation Pumps
   a. Number of Units: Two
   b. Configuration: Vertical Dry Pit
   c. Capacity and Head: [___] gpm at [____] feet TDH
   d. Secondary design point: [___] gpm at [___] feet TDH
   e. Minimum Efficiency as Design Capacity: [___] percent
   f. Pump Speed at Design Capacity (Maximum): [____]
   g. NPSH available [___] feeet.
   h. Minimum Solids Size: 4-in
   i. Minimum Shut-off Head: [___] feet
   j. Pump Runout at Maximum Speed: [___] gpm at [___] feet TDH
   k. Motor Type: Squirrel cage induction
   l. Motor Enclosure: TEFC
   m. Motor Hp: [____]
   n. Pump Discharge Size: [___]-in
   o. Pump Inlet Size: [___]-in

Comment [TJN3]: To be filled in when THP System Supplier is selected.

Comment [TJN4]: To be filled in when THP System Supplier is selected.

C. Chopper Pumps

1. The pumps shall be vertical dry pit, heavy duty, solids handling, non-clogging, chopper type pumps. The pumps shall be located as shown on the Drawings and as specified herein.

2. The pump casing material shall conform to ASTM A563 and be of semi-concentric design, with the first half of the circumference being cylindrical beginning after the pump outlet, and the remaining circumference spiraling outward to the 150 lb flanged centerline discharge. Back pull-out adapter plate shall allow removal of pump components from the casing and allow external adjustment of impeller-to-cutter bar clearance. Casing and adapter plate shall be ASTM A536 ductile cast iron with all water passages to be smooth, and free of blowholes and imperfections for good flow characteristics.

3. The impeller shall be semi-open type with pump out vanes to reduce seal area pressure, and to draw lubricant down from the reservoir should seal leakage occur. Chopping/maceration of materials shall be accomplished by the action of the cupped and sharpened leading edges of the impeller blades moving across the cutter bar at the intake openings, with a set clearance between the impeller and cutter bar of 0.015 to 0.025-in. Impeller shall be cast from ASTM A148, Grade 90-60 alloy, heat treated to minimum 60 Rockwell C hardness and dynamically balanced. The impeller shall be keyed to the shaft with a hardened steel

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bolt with washer, and shall have no axial adjustments or set screws. Fabricated impellers are unacceptable.

4. The cutter bar plate shall be recessed into the pump bowl and shall contain at least two shear bars extending diametrically across the intake opening to within 0.010-0.015-in of the rotating cutter nut tooth, for the purpose of preventing intake opening blockage and wrapping of debris at the shaft area. Cutter bar shall be T1 alloy steel plate heat-treated to minimum Rockwell C 60.

5. The upper cutter assembly shall consist of a specially modified impeller working against a stationary cutting ring mounted into the back pull out adaptor plate, in order to eliminate any build up of rags, hair, or other stringy material. The upper cutter shall be ASTM A148 Grade 90-60 cast alloy steel and heat treated to a minimum 60 Rockwell C Hardness.

6. Each pump shall have an alloy 20 welded metal bellows type mechanical seal with water flush, and be fitted with silicon carbide seal faces to provide long life expectancy in the presence of grit and abrasive solids. The seal shall ride on a Type 316 stainless steel shaft sleeve, with the seal bellows tension set by three set screws.

7. Alternatively, each pump shall have a flushless mechanical seal system specifically designed to require no seal flush: The seal shall be cartridge-type with Viton O-rings and silicon carbide faces. The cartridge seal shall be pre-assembled and pre-tested so that no seal settings or adjustments are required. Any springs used to push the seal faces together must be shielded from the fluid to be pumped. The cartridge shall also include a 17-4PH, heat-treated seal sleeve and an ASTM A536 ductile iron seal gland. The mechanical seal faces shall be lubricated and cooled by a separate oil chamber.

8. Shaft shall be AISI 4140 heat treated steel or equal. Shaft diameter will be a minimum of 1.5-in.

9. The bearing housing shall be ASTM A536 ductile cast iron, and machined with piloted bearing fits for concentricity of all components. Piloted motor mount shall firmly align motor stool on top of bearing housing.

10. Shaft thrust in both directions shall be taken up by either a double-row angular contact ball bearing or by two back-to-back mounted single-row angular contact ball bearings. Overhang from the centerline of the lower thrust bearing to the seal faces shall be a maximum of 1.2-in with a mechanical seat to isolate the bearings from the pumped media at operating temperatures to 250 degrees F. Thrust bearings shall be oil bath lubricated by I.S.O. Grade 46 turbine oil, with a minimum B-10 life rating of 100,000 hours.

11. The pump assembly shall be mounted vertically on a pump base with the motor vertically inline and above the pump.

12. A manual or automatic venting system shall be provided to vent the pump casing prior to start-up. For a top-discharge configuration, the vent shall be two-in NPT and tapped into the piping provided by the Contractor and the shop drawings shall clearly show this requirement including installation of a suitable valve. For a side-discharge configuration, the vent shall be through a 1/2-in NPT threaded connection on the side of the pump casing and an increaser for a two-in pipe. The shop drawings shall clearly show that the Contractor connects to the increaser with a suitable valve. For either type of pump casing,

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the discharge may be to either drain piping or back to the tank being mixed as shown on the contract drawings.

13. The motor shall be coupled directly to the pump shaft through a Falk all-metal flexible connector, T.G. Woods Sureflex Elastomeric or equal type coupling, with a minimum 1.5 service factor based on the drive rated horsepower, and shall be protected with a guard meeting OSHA requirements.

D. Motors

1. Motors shall be the minimum horsepower specified above, and shall be 1170 RPM, TEFC, 1.15 service factor and shall be as specified in Section 16150.

2. Motors shall not be required to deliver more than its rated nameplate horsepower, at 1.15 service factor, under any condition of mechanical or hydraulic loading.

E. Variable Frequency Drive

1. The THP System Supplier shall supply the variable frequency drives required to operate the pumps as specified.

2. Refer to Specification 16370 for general requirements for variable frequency drives.

F. Controls

1. General:
   a. THP System Supplier shall provide all instruments and controls required to integrate the pumps into the THP system automation.
   b. See Division 13 for general requirements of instrumentation associated with the THP system.

2. Equipment:
   a. Pressure Transmitters
   b. Level Switches
   c. Temperature Switches
   d. Flow Meters

Comment [TJN5]: More detailed to be provided once THP System Supplier is selected.

G. Base

1. The pump and motor shall be mounted on a common base of welded steel, arranged to collect drainage to a minimum one-in pipe-away drain connection. Provide grout holes for grouting under the common base to the concrete base.

2.03 SURFACE PREPARATION AND SHOP PRIME PAINTING

A. Surface preparation and shop priming is included as part of the work of this Section and Section 09901. Finish paint shall be as specified in Section 09902.

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2.04 FACTORY TESTING

A. Factory performance tests shall be conducted and the results submitted to and approved by the Engineer prior to shipment of the equipment.

1. The Manufacturer shall factory test all pumps prior to shipment in accordance with the Hydraulic Institute standards, 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 herein. A complete test report for each pump, including certified characteristic curves of the pump, consisting of at least head, flow rate, efficiency, and horsepower, and certified copies of the hydrostatic test report shall be submitted to and approved by the Engineer before the pumps are shipped. Certified test curves for each tested speed shall be provided for the following:
   a. Hydraulic efficiency
   b. input power KW
   c. Wire to water efficiency
   d. Brake horsepower
   e. Flow vs. head
   f. Vibrometer readings in at least three planes
   g. Temperature readings
   h. Amperage readings

2. Each drive motor shall be factory tested as specified in Section 16150.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Installation shall include furnishing the required oil and grease for initial operation. The grades of oil and grease shall be in accordance with the manufacturer's recommendations. Anchor bolts shall be set in accordance with the manufacturer's recommendations.

B. Submit manufacturer's certification of installation.

3.02 INSPECTION AND TESTING

A. After all pumps have been completely installed and made ready for operation, the pumps shall be started and run over the entire range of specified conditions, and demonstrate the ability to operate without overheating of bearings and motor, and without excessive vibration.

B. After the pumps have been completely installed, the Contractor (working under the direction of the manufacturer) shall conduct in the presence of the Engineer, such tests as are necessary to indicate that pump efficiency and discharge conform to the specified requirements. Field tests shall include all pumps included under this section. Supply all electric power and power or wastewater to complete the field tests.

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C. If the pump performance does not meet this section's requirements, corrective measures shall be taken, or pumps shall be removed and replaced with pumps which satisfy the conditions specified. Each pump shall operate for a total of 24 hours before acceptance and shall operate without excessive noise, vibration or overheating.

D. The pumps and motors shall be designed and constructed to avoid the generation of objectionable noise or vibration. The sound pressure level at full load shall not exceed 85 dBA, when measured at any point three feet from the pump and/or motor. When operating at any point between no-load and full-load, the vibration measured in a horizontal plane at the top of the motor shall not exceed 0.01 in/sec with displacement not to exceed 0.10 mils peak to peak.

E. Any component parts which are damaged as a result of testing or which fail to meet the requirements of these specifications shall be replaced, reinstalled and retested at no additional cost to the Owner.

END OF SECTION

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SECTION 11351
THERMAL HYDROLYSIS SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, install, test, and put into operation an automated thermal hydrolysis process (THP) for treating pre-dewatered waste activated sludge (WAS) and fats, oils and grease (FOG), complete, in place as shown on the Drawings and as specified herein.

B. The City of Franklin (Owner) has pre-selected the THP equipment for the Franklin WRF Modifications and Expansion Project (Project), a part of which involves the installation of a new THP system. As such, CDM Smith will act as the Engineer. The General Contractor will be responsible for the purchase of the THP system for the Project from _____ (THP System Supplier), based on the requirements set forth herein.

C. The THP system shall be furnished and installed with all necessary accessory equipment including, but not limited to, pre-dewatered sludge storage bins, progressing cavity pumps, pressure vessel(s), dilution/cooling water pumps, heat exchangers, an air compressor system, associated valves and piping, heat tracing and insulation, off-gas treatment and conveyance system and all system instrumentation and controls, whether specifically mentioned in this Section or not, as required for an installation incorporating the highest standards for the type of service including field testing and instructing the regular operating personnel in the care, operation, and maintenance of all equipment. All equipment and ancillary items provided as part of this equipment specification shall be new, field tested and proven effective for the intended service, and shall meet the requirements specified in the following sections.

D. The THP System Supplier's proposal is provided, for informational purposes, in Appendix __. This proposal is not part of the Contract Documents.

E. Furnish, test, and put into operation all interconnecting data and power cables required for a complete operating system. The THP System Supplier shall furnish all raceways integral to the THP system. Installation of raceways shall be by the General Contractor. The General Contractor shall install (pull) the THP System Supplier supplied cables.

F. The THP System Supplier shall provide all termination connections, power and data cabling, and raceways from the provided 480V power source to all THP system devices. The incoming power supply, conduit, and all field terminations and interconnections for power and data cables will be the responsibility of the General Contractor.

G. Furnish, test, and put into operation all instrumentation and controls equipment necessary including, but not limited to, programmable controllers, operator interface devices, appropriate networking devices, indicators, control stations, controllers, alarm enunciators, push buttons, lights, selector switches, power, and control as required for a complete operational system. Panels shall be constructed in accordance with requirements identified herein. The THP System Supplier shall coordinate with the General Contractor for proper interface of the THP system controls with the plant control system. The THP System Supplier shall be responsible for

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providing all hardware, software and firmware including development of drivers if required for interface with the plant control system. The THP System Supplier shall be present for and conduct testing as described herein. The THP System Supplier shall provide onsite supervision of the General Contractor and his subcontractors as described herein.

H. For purposes of standardization, and to achieve a common operator interface for control systems within the facility, the major items of instrumentation and process control equipment provided for the THP system local control panels shall be compatible with the plant instrumentation and control system specified in Division 13.

1. This equipment shall include but not be limited to programmable logic controllers and operator interface devices.

2. The Project includes instrumentation and controls improvements. The existing control architecture will be replaced as described in the Division 13 Specifications and on the Drawings. Refer to Paragraph 2.13 for instrumentation and controls requirements.

3. The THP System Supplier shall coordinate with the Project instrumentation and control system supplier to ensure compatibility of control circuits and proper interface of the THP system controls with the plant control system.

I. The THP system shall be capable of producing Class A Biosolids, as defined in US EPA 40 CFR Part 503, from pre-dewatered waste activated sludge (WAS) and fats, oils, and grease (FOG) with characteristics listed in this Section.

1.02 RELATED WORK

A. Concrete work is included in Division 03.

B. Miscellaneous metals are included in Division 05.

C. Special equipment, except as specified herein, is included in Division 11.

D. Instrumentation work, except as specified herein, is included in Division 13.

E. Mechanical work, except as specified herein, is included in Division 15.

F. Electrical work, except as specified herein, is included in Division 16.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, complete shop and installation drawings of all materials and equipment furnished under this Section. Submittals shall include the following:

1. A complete bill of materials listing all items to be supplied, including a complete HP list for all electrical equipment.

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2. Detailed drawings showing all details of construction of the THP system and ancillary equipment, and installation details of all equipment including anchor bolt sizes and locations.

3. The total weight of the equipment, including individual weights of the larger components.

4. Mass and energy balance sheets, electrical one line diagrams, and process and instrumentation drawings for the entire THP system.

5. All interconnections and interface requirements, dimensions, and locations of all major elements of the THP system including critical clearance requirements.

6. Catalog information and cuts for all manufactured items, including control system components, highlighted to show actual items proposed to be provided.

7. Supporting calculations for the structural design of the equipment sizing, equipment anchorage, and associated supports. All non-standard structural support needs of the equipment shall be designed and stamped by a Professional Engineer licensed in the State of Tennessee.

8. Detailed schematic and layout drawings and a description of operation of all control panels.

9. Panel construction and panel layout drawings. Panel construction drawings shall show the location of all panel-mounted devices, doors, louvers, and other features. Drawings shall be to scale and include a panel legend identifying all devices, manufacturers, type numbers, tag numbers, and all nameplate inscriptions. Interconnection diagrams shall show all point to point wiring diagrams between all equipment, panel, terminal, junction boxes, and all field-mounted components. The panel submittals shall include heat rise calculations to determine the size of an enclosure cooling system.

10. A description of how the THP System Supplier will achieve certification as an equivalent Class A technology as defined by EPA Part 503 regulations.

11. Complete manufacturer's specifications, including parts list citing materials (with ASTM UL/CSA, IEC designations, etc.).

12. Hydraulic calculations, and all assumptions, used in sizing all the THP system pumps.

13. Memory map of PLC registers to the Process Control System Supplier (PCSS).

14. Control narratives and graphics screens.

B. Design Data

1. Provide basis of design for this project, including background data, calculations, test reports, and other information showing the development of the proposed design and that it will conform to the requirements of Paragraph 1.06.

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C. Certificates

1. Provide an unexecuted copy of the Warranty Bond required in Paragraph 1.08.

2. Provide the testing reports (Startup, Functional Performance, Harmonics, Final Acceptance) and manufacturer's certification as required in PART 3.

D. Operation and Maintenance Data

1. Complete operation and maintenance manuals shall be submitted in accordance with Section 01730.

E. Testing procedures, requirements, and results as specified in Part 3.

F. Should the submittal include any items not in compliance with this section and/or the Drawings, provide a full description of the non-complying aspects for the Engineer's review.

1.04 REFERENCE STANDARDS

A. American Society of Civil Engineers (ASCE)

B. American Institute of Steel Construction (AISC)

C. American Iron and Steel Institute (AISI)

D. American National Standard Institute (ANSI)

E. American Society of Mechanical Engineers (ASME)

F. American Society for Testing & Materials (ASTM)

G. American Welding Society (AWS)

H. Heat Exchanger Institute (HEI)

I. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 519 – Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

J. National Association of Corrosion Engineers (NACE)

K. National Electrical Code (NEC)

L. National Electrical Manufacturer's Association (NEMA)

M. National Institute of Standards and Technology (NIST)

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N. National Water Research Institute (NWRI)

O. Occupational Safety and Health Association (OSHA)

P. "Standard Methods for the Examination of Water and Wastewater," APHA/AWWA/WEF.

Q. Tubular Exchanger Manufacturers Association Standards (TEMA)

R. Underwriters Laboratories (UL)

S. 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 THP system shall be designed, fabricated, assembled, and tested by

Comment [TJN1]: To be filled in after selection of THP System Supplier.

B. THP System Supplier's Representative

1. The services of an employee of the THP System Supplier shall be provided on the project site as the THP System Supplier's representative. The representative shall have complete knowledge of the equipment provided, including its proper installation, operation, and maintenance.

2. The THP System Supplier's representative shall inspect the installation and supervise any required modifications, additions, or other changes required to allow the THP System Supplier to certify per Paragraph 3.07 that the complete installation is appropriate and is expected to operate as expected.

3. The THP System Supplier's representative shall instruct the Owner's and Engineer's personnel on the operation and maintenance of the THP system. The instruction shall include classroom training on THP technology and the specific installation, and field training on proper operation and maintenance procedures, along with complete demonstrations of the same.

4. The THP System Supplier's representative shall supervise the functional testing, commissioning, and acceptance testing of the installation.
    1. The THP System Supplier's representative may enlist the help of manufacturer's representatives of specific equipment included in the THP system. In this scenario, the equipment manufacturer shall provide the services of factory trained specialists to assist the Contractor during testing and commissioning activities, including assistance with preparation of all required documentation, data summaries, plans and reports, as specified in this Section and in Appendix XX to the Contract.

Comment [TJN2]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

5. The THP System Supplier's representative shall provide minimum services in accordance with the following table.

Purpose	Minimum No. of Days

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Installation Supervision	10
Startup and Functional Testing	10
Commissioning	90
Overall THP O&M Training	5
Intensive Acceptance Testing	30
Optimization and Operator Shadowing	60

1. Installation Supervision
   1) The THP System Supplier's Representative shall inspect and certify the installation of all pieces of equipment that make up the THP system OR the representative shall acquire the services of a manufacturer's representative to inspect and certify the installation for the specific equipment they supplied.
   2) Additionally, the THP System Supplier's Representative shall inspect and certify the installation of the overall THP system.
2. Startup and Functional Testing
   1) The General Contractor will require the THP System Supplier's Representative to assist in the startup and functional testing. This includes, but is not limited to:
      a) Developing and supervising the startup and test procedures for THP system equipment, as well as compiling a written report of the tests as described in Attachment XX.
      b) Assisting the General Contractor in startup or functional testing of equipment that is outside the scope of the THP System Supplier, but whose startup or testing requires inputs/outputs from/to the THP system.
3. Commissioning
   1) The General Contractor will require the THP System Supplier's Representative to assist in the commissioning of the biosolids plant. This includes, but is not limited to:
      a) Developing and supervising the commissioning procedures for THP system equipment, as well as compiling a written report of the tests as described in Attachment XX.
      b) Assisting the General Contractor in commissioning of equipment that is outside the scope of the THP System Supplier, but who's commissioning requires inputs/outputs from/to the THP system.
4. Operation and Maintenance (O&M) Training
   1) The THP System Supplier's Representative shall present the O&M training to plant staff for all pieces of equipment that make up the THP system OR the representative shall acquire the services of the individual equipment manufacturer's representative to conduct O&M training for their specific equipment supplied.
   2) Additionally, the THP System Supplier's Representative shall conduct training on the operation of the overall THP system.
   3) See Specification 01664 for detailed requirements of O&M Training.
5. Intensive Acceptance Testing

Comment [TJN3]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

Comment [TJN4]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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1) The General Contractor will require the THP System Supplier's Representative to assist in the acceptance testing of the biosolids plant. This includes, but is not limited to:
   a) Developing and supervising the acceptance testing procedures for THP system equipment, as well as compiling a written report of the tests as described in Attachment XX.
   b) Assisting the General Contractor in acceptance testing of equipment that is outside the scope of the THP System Supplier, but whose testing requires inputs/outputs from/to the THP system.
2) The THP System Supplier's Representative will be solely in charge of the acceptance testing of the Class A Biosolids Performance Guarantee. See Attachment XX for more information on all of the performance guarantees.

6. Optimization and Operator Shadowing
   1) Upon completion of the Acceptance Testing, the THP System Supplier's Representative shall operate and optimize the THP system for 60 days.
   2) During this period, Franklin WRF has the option of having operators shadow the THP System Supplier's Representative to gain experience with the system's operation.
      a) Franklin WRF is manned 24 hours a day, 7 days a week (24/7); the THP System Supplier shall provide on-site personnel 24/7 during this 60 day period to allow plant staff on all 3 shifts ample time for shadowing. The System Supplier should budget to have multiple operation personnel at Franklin during these 60 days to be able to provide 24/7 on site operation.

6. The number of days indicated above shall be provided on an 8-hour day onsite basis with the exception of operator training, which shall be provided on site as specified in Section 01664. The number of days shall be in addition to travel time.

7. The acceptance of O&M training shall be in accordance with the successful completion of the "Equipment Manufacturer's Certificate of Instruction" as provided in Section 01730. This certificate shall be completed by the THP System Supplier's representative and the Owner at the completion of each vendor training session.
   1. This instruction period shall be scheduled at least 10 days in advance with the Owner and shall take place prior to plant startup and acceptance by the Owner. The final approved copies of operation and maintenance manuals specified in Section 01730 (three paper copies and three CDs) and copies of approved training materials must have been delivered to the Owner prior to scheduling the instruction period with the Owner.

8. Additional days onsite, if requested by the Owner, shall be based on an 8-hour day of onsite services, the rate for which shall be negotiated between the Owner and THP System Supplier.

9. Warranty service scheduling shall be provided, at the Owner's request, and at no additional cost to the Owner, at any time during the warranty period specified in paragraph 1.08.

Comment [TJN5]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

Comment [TJN6]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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1.06 DESCRIPTION OF SYSTEM

A. The equipment specified herein shall be designed to heat and pressurize screened, pre-dewatered WAS and FOG with flow and composition as listed in paragraphs 1.06.C and 1.06.D, respectively. The THP system shall treat the WAS and FOG as required to meet Class A pathogen reduction criteria as specified in US EPA 40 CFR Part 503.

B. The THP system shall be rated to process and hydraulically pass the maximum month flows.

1. If the THP supplier does not allow the FOG to pass through the THP reactor, the THP System Supplier shall provide a separate pasteurization system in order to treat the FOG to Class A Biosolids standards.

C. Biosolids treatment processes upstream of the THP system include sludge screening and pre-dewatering.

D. Pre-Dewatered, Screened, Waste Activated Sludge (WAS) Characteristics to THP System

1. Pre-dewatered, screened WAS is conveyed into the THP System Supplier's scope at the pre-dewatered sludge storage bin.

2. The THP System Supplier is to design the THP system to initially process, at a minimum, year 2025 maximum month loads, with the ability to build out to handle year 2040 maximum month loads. During initial startup, the THP system will experience year 2018 loads.

3. The below table lists the solids loading rates and characteristics of the screened, pre-dewatered WAS over the life of the THP system.

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	20,173	26,225	26,897	34,966	43,035	55,946
TS (%)[1]						
Flow Rate (gal/day)						
Flow Rate (WT/day)						
VS as % of TS (%)[2]	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%
VS (lb/day)	13,112	17,046	17,483	22,728	27,973	36,365

[1] Due to the limited dewaterability of WAS, the maximum % solids cake that can be provided is 22%.
[2] The expected volatile solids (VS) average is 65% of the total solids; however the Supplier should expect to see a range between 60-70% VS.

Comment [TJN7]: To be added once THP System Supplier is selected. This shall not exceed 22% solids.

Comment [TJN8]: This is a function of the TS %, which will be populated once the THP System Supplier is selected.

Comment [TJN9]: This is a function of the TS%, which will be populated once the THP System Supplier is selected.

4. "Initial Startup Loads" represents the predicted annual average day and maximum month loading rates and characteristics of the WAS for year 2018, which is during the initial startup of the system.

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5. "Phase 1 Design Loads" represents the predicted annual average day and maximum month loading rates and characteristics of the WAS for year 2025.

6. "Phase 2 Design Loads" represents the predicted annual average day at maximum month loading rates and characteristics of the WAS for year 2040.

E. FOG Flow Rates and Characteristics to the THP System

1. The FOG is passes through a rock box and is heated and mixed in storage tanks before being conveyed to the THP System Supplier's equipment pad; the THP System Supplier is responsible for routing the FOG to its point of treatment. That point of treatment may be the thermal hydrolysis reactor(s) or a separate pasteurization treatment system.

2. The THP System Supplier is to design the THP system to initially process, at a minimum, year 2025 maximum month loads, with the ability to build out to handle year 2040 maximum month loads. During initial startup, the THP system will experience year 2018 loads.

3. The below table lists the projected flow rates and characteristics of the FOG over the planning period.

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	811	877	1,068	1,158	1,925	2,085
TS (%)[1]	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
Flow Rate (gal/day)	2,431	2,629	3,201	3,471	5,770	6,250
Flow Rate (WT/day)	10.14	10.96	13.35	14.48	24.06	26.06
VS as % of TS (%)[2]	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
VS (lb/day)	689	745	908	984	1,636	1,772

[1] The expected total solids (TS) average is 4%; however the Supplier should expect to see a range between 4-10% TS.

[2] The expected volatile solids (VS) average is 85% of the total solids; however the Supplier should expect to see a range between 80-90% VS.

4. "Initial Startup Loads" represents the predicted annual average day and maximum month loading rates and characteristics of the FOG for year 2018, which is during the initial startup of the system.

5. "Phase 1 Design Loads" represents the predicted annual average day at maximum month loading rates and characteristics of the FOG for year 2025.

6. "Phase 2 Design Loads" represents the predicted annual average day at maximum month loading rates and characteristics of the FOG for year 2040.

F. Plant Reuse Water

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1. The plant reuse water (chlorinated effluent water) shall be provided to the THP system for use as seal water, dilution water and cooling water needs.

2. Below is relevant information on the plant reuse water.
   1. Water Temperature (degrees F)
      1) Maximum, approx. 81
      2) Minimum, approx. 53

G. High Pressure Steam

1. High pressure saturated steam shall be provided to the THP system for use as a heat source to process the incoming WAS and FOG. The steam will be produced by the combined heat and power (CHP) system outside of the THP System Supplier's scope, and delivered via insulated pipes to the THP equipment pad; the THP System Supplier is responsible for routing the steam from the equipment pad to its required application points.

2. Below is relevant information on the high pressure saturated steam.
   1. Pressure XXX pounds per square inch
   2. The mass flow rates required by _____, based on WAS and FOG flows listed in Paragraphs 1.06.D and 1.06.E, are shown in the table below.

Comment [TJN10]: To be filled from selected THP System Supplier's proposal.

Comment [TJN11]: To be filled in with winning THP System Supplier.

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
Saturated Steam Flow (lbs/hr)	X,XXX	X,XXX	X,XXX	X,XXX	X,XXX	X,XXX

Comment [TJN12]: To be filled from selected THP System Supplier's proposal.

3. The THP System Supplier shall be responsible for accepting the steam and controlling its application to appropriate points within the THP system.

H. THP System Redundancy

1. The below minimum redundancy requirements for individual components of the THP system shall be provided.
   1. Pre-dewatered Sludge Storage Bins
      1) One duty and one standby
   2. Progressing Cavity Pumps
      1) One standby pump per duty pump
   3. Water Service Pumps
      1) One standby pump per duty pump
   4. Chopper Pumps
      1) One standby pump per duty pump
   5. Air Compressor System
      1) One standby compressor per duty compressor
   6. Electrical

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1) One local control panel for each piece of equipment (i.e. if a system has a duty pump and a standby pump, there shall be two control panels, each dedicated to a single pump).

I. Class A Equivalent Technology Certification

1. The THP system is to produce Class A biosolids, which will be defined as achieving certification as a Class A equivalent technology as defined by EPA Part 503 regulations.

2. The THP System Supplier is responsible for all of the costs and effort associated with achieving this certification; these efforts include, but are not limited to,
   1. Coordinating with the appropriate EPA and TDEC officials,
   2. Hiring an approved laboratory to complete tests on all analytical samples, and
   3. Coordinating with the General Contractor.

3. Achieving certification as a Class A Equivalent Technology is a performance guarantee.

J. Guaranteed System Performance

1. General
   1. The Guaranteed system performance requirements are described in detail in Appendix XX.

Comment [TJN13]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

1.07 MAINTENANCE

A. Spare parts shall be provided with the THP system. The parts shall not be used or consumed by the THP System Supplier or Contractor and shall be transferred in new condition, free of defects, to the Owner upon Substantial Completion. The parts shall be provided in sturdy containers, labeled on all sides with information concerning the contents, and suitable for long-term storage in a room without environmental controls.

B. The following spare parts shall be provided:

1. 10 percent spare parts for valves, actuators, and instruments.

2. One spare rotor, stator for every duty progressing cavity pump.

3. Manufacturer's standard stock of spare parts for each size and type of pump and compressor.

4. Manufacturer's standard stock of spare parts for each size and type of electric motor operator provided.

5. Provide one spare PLC I/O module of each type used.

6. Provide one spare PLC power supply of each type used.

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C. Spare parts pricing are the same as those provided by the THP System Supplier during the proposal process. The prices for each of these items as of [Month] [Year], the date of the accepted THP proposal, are as follows:

1.
2.
3. The escalation of the spare parts prices above shall be tied to the "General Purpose Machinery and Equipment" commodity group, which has a commodity code of 11-4 in the Producer Price Index (PPI). This unadjusted commodity index can be found in Table 6 on the Bureau of Labor Statistics website. The web address is http://www.bls.gov/news.release/ppi.t06.htm. The index for "General Purpose Machinery and Equipment" in [Month] [Year] was [index value]. The spare parts pricing shall be adjusted annually each month using the formula below:

   Spare Part Replacement Cost (Current Year) =

   Spare Part Price ([Month] [Year]) x PPI ([Month] of Current Year) / PPI ([Month] [Year])

D. All tools, other than those commonly found in a mechanic's tool box, as required for maintenance and repair of the THP system, shall be provided in a metallic tool chest labeled as being the tools for this system.

1.08 WARRANTY

A. The equipment furnished under this section shall be free of defects in materials and workmanship, including damages that may be incurred during shipping, storage, and installation for a period of 18 months from the date of startup, which is defined as the day all of the acceptance testing has been approved by the Owner.

B. In addition to the standard equipment warranty described above, the THP System Supplier shall provide to the Owner a performance warranty bond equal to the THP equipment contract amount as guarantee that the installed system meets all performance guarantees listed in Appendix XX. The bond shall be for a term of 18 months from the date of written acceptance/approval of the THP system by the Engineer and the Owner.

1.09 PROGRESS PAYMENTS

A. Progress payments to the Contractor shall not exceed the following unless agreed to by the Owner:

Comment [TJN14]: Spare part items, prices, index value, and dates in these paragraphs to be filled in per the winning THP System Supplier's proposal.

Comment [TJN15]: Date of signed Pre-Selection Agreement.

Comment [TJN16]: To be filled in as of the latest release of the index on the date of the signed agreement.

Comment [TJN17]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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	Milestone	Payment (Cumulative Percent of Total Order Price Less Retainage)
1.	Approval by Engineer of Shop Drawing Submittal	5
2.	Delivery of System to Job Site	55
3.	Acceptance of Functional Testing	80
4.	Completion of O&M Manuals and Training	90
5.	Acceptance of Commissioning	95
6.	Acceptance of Performance Testing Report,	100

B. The progress payments listed above do not include the costs:

1. For the Warranty Bond

2. To achieve certification as equivalent Class A technology

3. For the Optimization and Operator Shadowing period

4. For the payment and performance bonds.

C. Refer to Specification 01025A for details on measurement and payment to the THP System Supplier.

1.10 DELIVERY, STORAGE AND HANDLING

A. Delivery of the components of the THP system shall be FOB to the jobsite. The General Contractor shall inspect the equipment upon delivery for defects or damage. If damage is found, the THP System Supplier shall be responsible for all additional shipping and fabrication costs to repair or replace the equipment. If no damage is found, the General Contractor shall sign off on the delivered equipment.

B. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation.

C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

D. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

E. 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.

F. Each box or package shall be properly marked to show its net weight in addition to its contents.

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G. Manufacturer shall assume responsibility for packaging to prevent normal transit and handling damage.

H. Finished surfaces of all exposed openings shall be protected by wooden blanks, strongly built and securely bolted thereto or by other approved means.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. General

1. Provide all new materials and equipment free from any defects.

2. Where two or more units of the same type of material or equipment are required, provide products of a single manufacturer.

3. See Specification 11000 for general requirements of equipment to be provided.

4. See Specification 11002 for requirements on equipment supports, grouting, and installation.

B. THP Equipment

1. The THP System Supplier shall provide its standard equipment provided it meets the minimum requirements set forth in this Specification.

2. The subparagraphs below detail requirements for specific equipment. It is understood that not every piece of equipment listed below is required for all THP System Suppliers. If a subparagraph is not applicable to your proposal for this THP system, state so in your submittal.

3. All areas where the THP equipment is to be provided are anticipated to be unclassified per NFPA 820.

2.02 PRE-DEWATERED SLUDGE STORAGE BINS

A. Two pre-dewatered sludge storage bins shall be supplied by the THP System Supplier. The bins shall be located inside of the pre-dewatering building in an unclassified environment.

B. The pre-dewatered sludge storage bins shall each be sized to hold a minimum of 6 hours of storage under phase 2 maximum month loads listed in Paragraph 1.06C.

C. The THP System Supplier shall provide connections for the pre-dewatered sludge conveyance system and the odor control system. The contractor will tie the pre-dewatered sludge conveyance system and odor control system into these connections.

D. See specification 11243 for details on requirements for the pre-dewatered sludge storage bins.

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2.03 PROGRESSING CAVITY PUMPS

A. All progressing cavity pumps associated with the THP system shall be supplied by the THP System Supplier.

B. All pumps conveying sludge within the THP system shall be progressing cavity type. The pump manufacturer shall provide information on the stator bond technology being used for this high temperature application, as well as an installation list of where their proposed pump has been used in hydrolyzed sludge applications.

1. The THP feed pumps will deliver sludge from the pre-dewatered cake storage bin to the THP process. These progressing cavity pumps will be under the pre-dewatered cake storage bin in the pre-dewatering building

2. All other progressing cavity pumps shall be located on the THP manufacturer's concrete pad and/or in the digester building, depending on which THP system supplier is selected.

C. See specification 11315A for details on requirements for the progressing cavity pumps.

2.04 WATER SERVICE PUMPS

A. The THP System Supplier shall provide all water service pumps required to operate the THP system. These pumps include, but aren't limited to, dilution water pumps and cooling water supply pumps for heat exchangers.

B. Water service pumps shall be either centrifugal or axial-flow pumps that meet the minimum requirements of Specification 11050.

C. The dilution and cooling water pumps shall receive potable or disinfected plant effluent (plant reuse water).

D. All water service pumps shall be located on the THP manufacturer's concrete pad.
1. The exception to this is the cooling water pumps for the heat exchangers. These pumps will be located inside the digester building.

2.05 PRESSURE VESSELS

A. The THP System Supplier shall provide the pressure vessel(s) and steam control equipment required to heat and pressurize the sludge per the manufacturer's design requirements.

B. The vessel(s) shall be in accordance with the latest edition of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1. Vessel(s) shall be designed:
1. For an outdoor location with ambient climate conditions and local geotechnical factors.
2. For the intended use. The vessel(s) materials shall be compatible with the heated sludge.

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3. To heat and pressurize the maximum month pre-dewatered WAS and FOG loading (if processed in the same vessel), listed in Paragraph 1.06C and 1.06D, for the required time period to produce Class A Biosolids per US EPA 40 CFR Part 503.

2. All welds shall be in accordance with the requirement of the ASME Boiler and Pressure Code Division 1 for Unified Pressure Vessels. In those areas where ASME code is silent or vague regarding workmanship, weld profile, and sizes, the requirements of AWS D1.1 shall govern.

3. All welding procedures, procedure qualifications, and welding are to be in accordance with ASME Code Section VIII and IX.

4. Welds shall be continuous. Partial welds will only be accepted if sufficient cutouts between weld segments are included in order to avoid crevice corrosion. Welds shall be pickled and passivated according to applicable standards.

5. The vessel(s) shall incorporate rupture disks to protect the tank from experiencing pressures greater than what the vessel(s) can safely handle. In the event the rupture disk is needed, the off gas shall be contained, cooled, and conveyed to the anaerobic digesters.
   1. The treatment of the off gas shall include an air cooling system, an activated carbon filter, and all other appurtences required for the cooling, treatment, and automation of the system.
   2. The system shall be designed to handle the temperature and composition of gas and steam entering the system.
   3. The THP System Supplier shall supply the off gas cooling and treatment system detailed above.
   4. The Contractor shall supply the treated gas conveyance pipe from the system to the digesters.
   5. The Contractor shall pipe cooling water supply and return pipes to and from the off-gas cooling system. The THP System Supplier shall provide the heat exchanger and cooling water pumps as required for the off-gas cooling system.

6. The Contractor will supply piping to convey steam to the THP equipment pad. The THP System Supplier shall provide the piping (within the THP equipment pad) and steam equipment to control the application point and rate of steam injection into the pressure vessels.

2.06 VALVES AND ACTUATORS

A. All automated and manual valves required to control the THP system shall be supplied by the THP System Supplier.

B. All valves shall be rated for the temperature and pressure of the THP system.

C. See Specification 15100 for minimum acceptable standards for valves.

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2.07 PIPING SYSTEMS

A. The THP System Supplier shall supply all piping, fittings, supports and specialties to provide a complete piping system. .

B. All piping shall be rated for the temperature, pressure and fluid of the THP system.

C. See the following specifications for general requirements of the THP piping systems. These are general specifications and not everything will be applicable to the THP system.

1. Section 15051 – Piping General Requirements

2. Section 15061 – Steel Pipe and Fittings

3. Section 15063 – Copper Pipe and Fittings

4. Section 15064 – Plastic Pipe and Fittings

5. Section 15066 – Stainless Steel Pipe and Fittings

6. Section 15072 – Ductile Iron Pipe and Fittings

7. Section 15120 – Piping Specialties

8. Section 15140 – Pipe Hangers, Supports & Restraints

2.08 HEAT TRACING, INSULATION AND CLADDING

A. The THP System Supplier shall supply all insulation, heat tracing and cladding required for the vessel(s), valves, piping and other mechanical equipment within the THP System Supplier's scope.

B. See the following specifications for minimum acceptable standards:

1. Section 15250 – Thermal Insulation for Process Pipe and Equipment

2. Section 15257 – Electrical Heat Tracing

2.09 AIR COMPRESSOR SYSTEM

A. The air compressor system required to operate the pneumatic control valves for the THP system shall be provided by the THP System Supplier.

B. The air compressor system shall be located on the THP manufacturer's concrete pad.

C. See Specification 11373 for requirements of the air compressor system.

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2.10 COOLING HEAT EXCHANGERS

A. Sludge/Water heat exchangers associated with the THP system shall be provided by the THP System Supplier.

B. The heat exchangers shall be located inside the digester building.

C. See Specification 15754 for minimum requirements for sludge/water heat exchangers.

2.11 CHOPPER PUMPS

A. Recirculation of digested sludge into the hydrolyzed sludge digester feed line is required, and shall be accomplished by chopper pumps.

B. The pumps shall be located inside the digester building.

C. See Specification 11318 for minimum requirements for recirculation chopper pumps.

2.12 VARIABLE FREQUENCY DRIVES

A. Variable frequency drives (VFDs) required for motors of process equipment associated with the THP system shall be provided by the THP System Supplier.

B. See Specification 16370 for minimum requirements for VFDs.

2.13 INSTRUMENTATION AND CONTROLS

A. The THP System Supplier shall supply all instrumentation and controls required to operate and automate the THP system.

B. The THP system shall be controlled by its own PLC (provided by the THP System Supplier), which will be integrated into the plant SCADA system (by the Contractor).

C. The central control panel (CCP) for the THP system shall be located in the electrical room of the solids handling building.

1. There shall be a local remote input/output panel (RIOP) in the electrical room of the digester building.

2. There shall be a local RIOP on the THP equipment pad.

3. The RIOPs shall be connected to the CCP via fiber optic cable.

D. See the following specifications for general requirements of the THP instrumentation and controls. These are general specifications and not everything will be applicable to the THP system.

1. Section 13300 – I&C General Provisions

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2. Section 13311 – PLC Hardware and Software

3. Section 13320 – Control and Data Network Equipment

4. Section 13321 – Fiber Optic Cabling and Equipment

5. Section 13330 – Control Panel Enclosures and Panel Equipment

2.14 ELECTRICAL

A. The Contractor will supply the 480V power sources to the THP equipment pad. The THP System Supplier is responsible for all electrical equipment required to route and control that power to the THP system. This includes wire, conduit, cable trays, light fixtures, control panels with motor starters and VFDs, if required. For THP equipment located in the Solids Processing Building or Digester Building, the electrical power shall be routed directly to the equipment control panels.

1. Control Panels shall be built in accordance with Section 16191A, and 16370 if VFDs are required.

B. See the following specifications for general electrical requirements of the THP System. These are general specifications and not everything will be applicable to the THP system.

1. Section 16000 – Electrical – General Provisions

2. Section 16110 – Raceways, Boxes, Fittings and Supports

3. Section 16120 – Wires and Cables

4. Section 16150 – Motors

5. Section 16191A – Miscellaneous Equipment (For THP Pre-Selection Only)

6. Section 16370 – Variable Frequency Drives

7. Section 16500 – Lighting Systems

PART 3 EXECUTION

3.01 INSTALLATION

A. The THP System Supplier's representative shall attend a pre-installation meeting with the Contractor and Engineer to review general procedures, erection and installation instructions, and installation sequence.

B. The THP System Supplier's representative shall inspect the installation and supervise any required modifications, additions, or other changes required to allow the THP System Supplier

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to certify per Paragraph 3.07 that the complete installation is appropriate and is expected to operate as expected.

C. Install the THP system in strict compliance with the THP System Supplier's instructions and recommendations.

3.02 GENERAL TESTING REQUIREMENTS

A. The THP System Supplier shall furnish the services of a trained technician as given in Paragraph 1.05 to supervise the startup and testing of the system. The system shall operate to the specified requirements. If the system fails to meet specified requirements, it shall be adjusted, repaired, and/or replaced at no additional cost to the Owner.

B. The Contractor shall provide the required manpower, equipment, and materials needed to conduct all tests, in accordance with Appendix XX. Provide the services of a certified independent laboratory, approved by the Engineer, to conduct all required laboratory analyses during performance testing, in accordance with Appendix XX.

1. The exception to this is that the THP System Supplier shall be responsible for providing the services of a certified independent laboratory to conduct all required laboratory analysis to meet the Class A equivalent technology performance guarantee.

3.03 FUNCTIONAL TESTING

A. The Contractor shall refer to Appendix XX for requirements and procedures for functional testing and commissioning.

B. The THP System Supplier shall assist the Contractor with all functional testing that requires the participation of the THP system.

3.04 ACCEPTANCE TESTING

A. The Contractor shall refer to Appendix XX for requirements and procedures for acceptance testing and commissioning.

B. The THP System Supplier shall assist the Contractor in all acceptance testing that requires the participation of the THP system.

3.05 SUPERVISION, CERTIFICATION, AND REPORT OF TESTING

A. The THP System Supplier's representative shall supervise the functional testing, analyze data, and certify the system's performance during the tests. Tests shall be documented during continuous operation of the system, and the THP System Supplier shall submit to the Engineer three copies of a complete report containing all data, calculations, lab report sheets, and a description of the preliminary performance testing procedures and results, including all acceptance testing of performance guarantees as described in Appendix XX. Once the final test is complete, the THP System Supplier shall submit to the Engineer three copies of a complete

Comment [TJN18]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

Comment [TJN19]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

Comment [TJN20]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

Comment [TJN21]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

Comment [TJN22]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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report containing all data, calculations, lab report sheets, and a description of all of the acceptance testing procedures and results.

3.06 ACCEPTANCE/NONACCEPTANCE OF SYSTEM

A. If, in the opinion of the Engineer and Owner, the system meets the performance requirements outlined in Appendix XX during the preliminary performance testing specified herein, and the Owner has received the executed Warranty Bond specified in Paragraphs 1.08 and 3.08, the Engineer will recommend to the Owner, by letter, the official acceptance/approval of the THP system. If, in the opinion of the Engineer and Owner, the test results do not meet the performance requirements during the preliminary performance testing specified herein, the Engineer will notify the THP System Supplier and the Owner in writing of the non-acceptable performance.

Comment [TJN23]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

B. In the case of non-acceptable performance, the THP System Supplier shall then have 60 days in which to perform, at the THP System Supplier's sole expense, any supplemental testing, equipment adjustment, changes, or additions and request an additional retest of the non-acceptable system.

C. Should the THP system fail to meet the requirements of the Specifications or the performance requirements after, the THP System Supplier shall remove the system at their own expense and shall refund all payments.

D. If the thermal hydrolysis system succeeds in meeting the specified Class A Biosolids requirements, but fails in meeting the Guaranteed:

1. Steam Consumption, OR

2. Percent Volatile Solids Destruction in the digesters, the Owner may choose to accept the equipment. If the Owner accepts the equipment in this case, liquidated damages will be assessed and levied on the THP System Supplier. The liquidated damages will be calculated on the basis of the Performance Guarantee that was not met. If multiple guarantees weren't met, the liquidated damages will be cumulative. The liquidated damages shall be calculated according to the following formulas. The maximum value of the liquidated damages shall be equal to the THP system price listed in the Bid Form.

Liquidated Damages in Dollars =

1. Steam Consumption
   1. If greater steam flow rates or pressures are required to achieve Class A biosolids than listed in the performance guarantee, more heat must be generated from the combined heat and power (CHP) system for a steady amount of biogas being produced. This requires Franklin to purchase more utility-grade natural gas (NG). The liquidated damages will equal the cost of this extra NG minus the cost of the additional electrical generation achieved from the CHP unit.

      $LD = $NG - $EG

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Where..
$LD = Cost of liquidated damages in dollars per day
$NG = Cost of additional utility grade natural gas purchased to provide the additional fuel needed to the CHP in dollars per day
$EG = Cost of additional electricity generated by the CHP engine in dollars per day.

2. Percent Volatile Solids Destruction (VSD)
    1. If less biogas is being produced than guaranteed, that means
        1) More NG needs to be purchased to run the CHP system
        2) More biosolids have to be dewatered, solar dried and disposed of.
    2. The liquidated damages will be equal to the cost of the additional NG needed to supplement the lack of biogas production and the cost to dewater, dry and transport the extra solids.
        1) The CHP system will be producing the same amount of heat and energy, so there will be no offset due to additional electrical generation.

$LD = $NG + $DW + $SD + $DIS - $REV
Where..
$LD = Cost of liquidated damages in dollars per day
$NG = Cost of additional natural gas purchased to provide the additional fuel needed to the CHP in dollars per day
$DW = Cost of dewatering additional flows of solids through the screw press in dollars per day.
$SD = Cost of drying additional flows of solids through the solar dryer in dollars per day
$DIS = Cost of hauling additional flows of solids off site in dollars per day
$REV = Cost of revenues made from selling Class A biosolids in dollars per day

3.07 MANUFACTURER'S CERTIFICATION

A. Submit a letter from the THP System Supplier stating that he has inspected the installation and checked its performance and certifies that the installation is satisfactory, that the system is operating correctly, and that the system meets all the requirements of this section.

3.08 WARRANTY BOND DELIVERY

A. Following installation, startup testing, and satisfactory completion of preliminary acceptance testing, delivery of all required parts, chemicals, documents, and other items required above, submit the executed warranty bond required in Paragraph 1.08 directly to the Owner.

END OF SECTION

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SECTION 11373
COMPRESSED AIR SYSTEM AND APPURTENCES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals necessary and install, complete and ready for operation, two rotary screw or reciprocating type air compressors complete with all accessories as shown on the Drawings and as specified herein.

B. Power factor correction capacitors conforming to the requirements of Section 16150 shall be furnished under this Section.

1.02 RELATED WORK

A. General Requirements for Equipment is included Section 11000.

B. Concrete is included in Division 3.

C. Field painting is included in Section 09902.

D. Instrumentation and control work, except as specified herein, is included in Division 13. Instrumentation and controls provided in this section shall adhere to Instrumentation and Control Specifications Sections in Division 13.

E. Mechanical piping, valves, pipe hangers and supports are included in their respective Sections of Division 15.

F. Electrical work, except as specified herein, is included in Division 16.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, copies of all materials required to establish compliance with this Section. Submittals shall include the following:

1. Certified shop and erection drawings showing all details of construction, dimensions and anchor bolt locations.

2. Descriptive literature, bulletins and/or catalogs of the equipment.

3. Requirements for cooling water including pressure, temperature and quantity.

4. A certified statement that the units will meet the noise level provisions of Paragraph 2.02K below. Test data on noise levels of similar units shall be submitted.

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5. A list of the manufacturer's recommended spare parts.

B. Operation and Maintenance Data

1. Complete operating and maintenance instructions shall be furnished for all equipment included under this Section as provided in Section 01730. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions that are required to instruct operation and maintenance personnel unfamiliar with such equipment.

2. A factory representative, who has complete knowledge of proper operation and maintenance, shall be provided to instruct representatives of the Owner on proper operation and maintenance. This work may be conducted in conjunction with the inspection of the installation and field tests as provided under PART 3.

1.04 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME)

B. National Electrical Manufacturers Association (NEMA)

C. Occupational Safety and Health Administration (OSHA)

D. 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 compressed air system shall be furnished by a single manufacturer who is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The compressed air equipment shall be designed, constructed and installed in accordance with the best practices and methods.

B. The air compressor system shall be by Kaeser Compressor, Quincy Compressor, Division of Colt Industries; Sullair Corp.; Worthington Corp. or equal.

C. Services of Manufacturer's Representative

1. The services of a full-time employee of the Air Compressor System Manufacturer shall be provided on the project site as the manufacturer’s representative. The representative shall have complete knowledge of the equipment provided, including its proper installation, operation, and maintenance.

2. The Manufacturer's representative shall inspect the installation and supervise any required modifications, additions, or other changes required to allow the Air Compressor System

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Manufacturer to certify that the complete installation is appropriate and is expected to operate as expected.

3. The manufacturer's representative shall provide minimum services in accordance with the following table.

Purpose	No. of Days
Installation Supervision	1
Startup and Functional Testing	1
Operator Training	2

4. The number of days indicated above shall be provided on an 8-hour day onsite basis with the exception of operator training, which shall be provided on site over the two days of training and shall be allocated at the Owner's discretion. The number of days shall be in addition to travel time.

5. The acceptance of O&M training shall be in accordance with the successful completion of the "Equipment Manufacturer's Certificate of Instruction" as provided in Section 01730. This certificate shall be completed by the THP System Supplier's representative and the Owner at the completion of each vendor training session.
   1. This instruction period shall be scheduled at least 10 days in advance with the Owner and shall take place prior to plant startup and acceptance by the Owner. The final approved copies of operation and maintenance manuals specified in Section 01730 (three paper copies and three CDs) and copies of approved training materials must have been delivered to the Owner prior to scheduling the instruction period with the Owner.

6. Additional days onsite, if requested by the Owner, shall be based on an 8-hour day of onsite services, the rate for which shall be negotiated between the Owner and THP System Supplier.

7. Warranty service scheduling shall be provided, at the Owner's request, and at no additional cost to the Owner, at any time during the warranty period.

1.06 DESCRIPTION OF SYSTEM

A. Normal operation of the air compressor system shall be such that one duty and one standby compressor will provide ultimate air requirements for the pneumatic control valve system for the thermal hydrolysis process.

B. Each package compressor unit shall consist of a

   1. Rotary screw,

   2. Skid mounted air compressor including

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1. Air intake filter
2. Modulating control valve
3. Air-oil separator reservoir
4. Air cooled after-cooler
5. Air cooled oil cooling system
6. Coalescing filter
7. Electric motor, motor starter and control panel

1.07 MAINTENANCE

A. Tools and Spare Parts

1. Furnish with each compressor unit the manufacturer's standard set of spare parts including at least the following:
   1. Four oil filters
   2. One oil separator element
   3. Belts on of each type and size

PART 2 PRODUCTS

2.01 GENERAL

A. All parts shall be so designed and proportioned as to have liberal strength and stiffness and to be especially adapted for the work to be done. Ample room and facilities shall be provided for inspection, repair and adjustment.

B. Stainless steel nameplates giving the name of the manufacturer, model number, serial number, the rated capacity, pressure ratings, speed, gear ratio and any other pertinent data shall be attached to each air compressor.

C. Stainless steel nameplates giving the name of the manufacturer, model number, serial number, rated horsepower, speed, service factor, power supply requirements and any other pertinent data shall be attached to each motor.

2.02 EQUIPMENT

A. The air compressor system shall supply high pressure and instrument quality air to the pneumatic control valves associated with the thermal hydrolysis process.

B. The air compressor system shall be designed and sized to provide air from X to XX scfm at XXX psig with one unit as standby. The system shall be capable of supplying the varying demands and maintain a constant XXX psig on a continuous basis. Each compressor shall have a minimum capacity of XX scfm. The compressors shall operate to meet maximum daily demands. The lead compressor shall operate continuously modulating its intake to meet demands from X to XX scfm.

Comment [TJN1]: To be filled in when THP System Supplier is selected.

Comment [TJN2]: TBD by the THP system supplier based on system needs.

Comment [TJN3]: TBD by the THP system supplier based on system needs.

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C. The two compressors shall be sized as follows:

1. Capacity at full load pressure XX scfm
2. Full load pressure1 XX psig
3. Maximum operating pressure XXX psig
4. Minimum operating pressure XX psig
5. Motor horsepower XX maximum
6. Nominal full load speed XXXX rpm

D. The air receivers shall be sized as follows:

1. Diameter XX -in
2. Height XX -in
3. Capacity XX gallon min.
4. Working Pressure XX psig
5. Air Inlet Pipe Connection XX -in
6. Air Outlet Pipe Connection XX -in
7. Pressure Relief Connection XX -in
8. Drain Pipe Connection XX -in

Comment [TJN4]: TBD by the THP System Supplier based on system needs.

E. Each compressor unit shall be a single stage, heavy duty, flood lubricated and cooled, asymmetrical rotary screw type electric motor driven packaged air compressor designed for continuous unattended service with separate radial and thrust anti-friction bearings mounted on each rotor. Each compressor shall be equipped with a heavy duty two stage, dry type inlet filter with maintenance indicator, a natural pressure oil cooling system with lubricant filter with replaceable element, air-oil separator (two stage coalescent type with return line, strainer, sight glass blow down valve and minimum pressure valve), ASME Code 175-psig rated receiver-separator tank with safety pressure relief valve, coolant filler to prevent overfilling and oil level gauge glass and a thermostatic temperature control valve, a power saving modulating control system modulating air inflow from 0 to 100 percent of capacity, a water cooled oil cooler with thermostatic control valve, a high discharge temperature shutdown device, a high discharge pressure shutdown device, a low discharge pressure shut down device, a low cooling pressure shutdown safety switch and an air cooled after-cooler mounted and piped as an integral component with moisture separator and automatic drain trap. Each compressor shall also be

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equipped with a NEMA 4 local control panel which shall contain the 120 Volt control power transformer, magnetic across-the-line motor starters with 3 Phase overload protection, air filter, bearing coolant filter, service coolant filter and separator, maintenance indicators, discharge temperature gauge, line pressure gauge, sump pressure gauge, coolant temperature gauge, hour meter, machine running light, indicator lights for high discharge air temperature shut down, high discharge pressure shut down, low discharge pressure shutdown and low coolant pressure shutdown and start-stop button. Separate contacts for all local trouble indicator lights on each compressor shall be wired to a common alarm such that the common alarm can be easily wired by others to a remotely located alarm. The compressor control panel shall also contain system lead/lag standby controls for two compressors.

F. Each compressor shall deliver not less than XX scfm of air when intake pressure is XX psia and discharge pressure is XX psig and also shall be capable of modulating its delivery down to 0 scfm. Each compressor shall have the capability of setting the operating pressure from XX to XX psig. Compressor system shall be complete with dual control and base load transfer switch. Each control panel shall be completely interwired internally requiring only external connections to the control panel terminal blocks.

Comment [TJN5]: To be filled in after selection of the THP System Supplier based on their system needs.

G. Electric motors for each compressor unit shall be rated XX Hp maximum, XX rpm maximum, horizontal, TEFC, and have the appropriate NEMA design for its environment (indoor or outdoor service) and shall be as specified under Section 16150. The motors shall be designed for full voltage starting. Motors shall be coupled to the compressor unit through lifetime non-lubricated flexible spacer type coupling. Motor and compressor combination shall be mounted on a heavy steel unitized subbase for positive alignment.

Comment [TJN6]: To be determined after the selection of the THP System Supplier.

H. All 120 Volt control circuit transformers shall have one side of their secondary winding fused and the unfused side grounded.

I. Each compressor unit shall be furnished factory mounted on a structural base with fork slots in ends for lifting. Units shall be set up for quick and easy hookup to external power sources and air distribution pipelines. The structural base shall be equipped with vibration absorbers.

J. The compressed air after-coolers shall be capable of cooling the maximum airflow to within 15 degrees of the entering cooling air temperature.

K. At all levels of performance, the air compressor units shall comply with OSHA noise exposure requirements for four hours exposure. The noise level measurement shall include noise from the motor, compressor and all auxiliary equipment furnished. Noise levels shall not exceed 85 dBa measured at four feet from equipment. Furnish compressor with all required noise abatement equipment and silencers to comply with noise requirement.

L. The air receivers shall be built to ASME standards and have National Board certificate. They shall have XX -in skirts. Tanks shall be vertical configuration, XX -in diameter by XX -in length. Working pressure shall be at least XX psig. Fittings shall include XX -in drain and a XX -in inlet and outlet. There shall also be a XX -in code approved safety relief valve set for XX

Comment [TJN7]: To be determined based on THP System Supplier's needs.

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psig plus necessary fittings to install it. Receiver tank sizing shall be confirmed by solids screening equipment manufacturer. Tank shall be located as shown on the Drawings.

M. Furnish a complete refrigerant style air dryer package system sized to match compressors flow and pressure. Air dryer system shall be designed to maintain a minimum dew point of XX °F. The air dryer system shall utilize a smooth tube heat exchanger with non-fouling surfaces to minimize pressure drop, have built in moisture sensors, and automatic condensate drain vales. Air dryer system shall be manufactured and furnished by compressor supplier to work as an integrated system with the compressor equipment furnished.

Comment [TJN8]: TO be determined after selection of the THP System Supplier.

2.03 SURFACE PREPARATION AND SHOP PRIME PAINTING

A. Shop priming and surface preparation is included as part of the work of this Section and shall be as specified under Section 09901.

PART 3 EXECUTION

3.01 INSTALLATION

A. The air compressor system shall be installed in accordance with the manufacturer's instructions and as shown on the Drawings.

B. A certified statement shall be issued by the manufacturer stating that the installation of his/her equipment is satisfactory, that the equipment has been properly lubricated and is ready for operation and that operating personnel have been suitably instructed in the operation, lubrication and care of each piece of equipment furnished.

3.02 FACTORY TESTS

A. Prior to shipment, each compressor unit shall be given a standard commercial running test and copies of the results submitted to the Engineer.

3.03 INSPECTION AND FIELD TESTS

A. Following installation, the equipment shall be operated for a sufficient break-in period to make final adjustments for proper operation. A factory representative of the manufacturer shall supervise this work.

B. After completion of the break-in period, an acceptance test shall be conducted by the manufacturer in the presence of the Engineer to determine that the equipment is in conformance with the requirements specified. The performance tests shall consist of 8 hours of operation at various demand conditions. The air compressors shall operate as specified under all design conditions without excessive noise or vibration. Readings of all essential data shall be taken and recorded at thirty minute intervals. A form of log sheet showing all items to be taken and recorded shall be submitted 15 days prior to field testing. Provide all labor, power, water and miscellaneous special equipment required for the test.

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C. Should the equipment fail to perform in accordance with the requirements specified, make such modifications as are necessary to provide satisfactory performance and retest the equipment at no additional cost to the Owner.

END OF SECTION

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SECTION 13300
INSTRUMENTATION AND CONTROLS – GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall procure the services of a Process Control System Supplier (PCSS) to furnish and install all materials, equipment, labor and services, required to achieve a fully integrated and operational system as specified herein, in the Specification Sections listed below, and in related Drawings, except for those services and materials specifically noted as provided by others.

Section No	Title
13302	I&C - Testing
13303	I&C - Training
13305	I&C - Control Descriptions
13306	I&C - Application Engineering Services
13310	I&C - Computer System Hardware
13311	I&C - PLC Hardware and Software
13315	I&C - HMI System Software
13320	I&C - Control and Data Network Equipment
13321	I&C - Fiber Optic Cabling and Equipment
13330	I&C - Control Panels and Panel Mounted Equipment
13340	I&C - Field Instruments

B. A summary of the PCSS's scope of work is as follows:

1. Provide all PLC and HMI equipment and programming as shown on the Drawings and described in the Specifications, encompassing both new and existing processes and sites, to produce a complete city-wide SCADA system.

2. Wastewater Reclamation Facility:
   a. Furnish instruments as shown on the Drawings and as specified in Section 13340.
   b. Furnish new PLC-based control panels for the Headworks Building (PLC-1A) and the new Electrical Building (PLC-10).
   c. Replace existing control panel enclosures for PLC-2 and PLC-3. Reuse the existing sub-panel and components, but provide new PLC as described below. Provide enough equipment and panel space to support all existing I/O currently installed, plus all new I/O shown on the Drawings, plus the required active spares. Appendix A of this Section provides information on existing enclosures for reference, subject to field verification by PCSS.
   d. For all other PLC locations: Replace the existing Allen-Bradley SLC Series PLCs on the DH+ network with new Allen-Bradley CompactLogix PLCs, as shown on the contract drawings. Reuse existing enclosures, terminals and wiring, etc., except as described above. Provide new I/O modules and other equipment to support all new I/O shown on the Drawings, in addition to all existing I/O currently installed. Furnish and install an Ethernet network switch capable of self-healing fiber ring topology.
   e. Remove all existing fiber optic cable, and furnish, install, terminate and test new 12-strand, 50/125 multimode fiber optic cable, to produce a self-healing network ring.

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f. Provide two PC Workstations with HMI software, and a report printer, as shown on the Drawings and described in the Specifications.
g. Reprogram the existing Maple Systems OIT database at the Filter Complex, PLC-8F, to communicate with the new CompactLogix PLC.
h. Provide a Maintenance of Plant Operations (MOPO) Plan for the work, describing the sequence of PLC, networking, and HMI replacement that will minimize system downtime. Schedule a meeting between the PCSS, Engineer and Owner to review and discuss the preliminary and final MOPO Plan.
    1) At a minimum the plan should contain the following information:
        a) Schedule of all activities (coordinated with overall construction schedule)
        b) List of major equipment groups, along with any dependencies on other plant processes.
        c) Sequence of equipment transition, along with operational constraints and anticipated transition time. The preliminary sequence below is provided as a guide to separating the existing DH+ and new Ethernet network and keeping all PLCs communicating, but will need verification:
            - PLC-1: Administration Building
            - PLC-2: Blower Building
            - PLC-3 and 3A: Return Sludge
            - PLC-9: RAS/WAS Pump Station
            - PLC-7: DAF Building
            - PLC-6: Sludge Dewatering
            - PLC-8F: Filter Complex
            - PLC-8: Influent Pump Station
            - PLC-4: Effluent Pump Station
        d) Table of equipment associated by PLC and process area. Table will show the maximum time the equipment can be run locally by operations staff, other related constraints, and critical systems.
        e) Work schedule shall including days of the week and times when work can be performed. Daily work schedules shall include, but not be limited to, the following:
            - Necessary preparation work
            - “Status and Go” meeting
            - Replacement goals and walkthrough
            - Settings and equipment checklist
            - Notification and approval of operations
            - Documentation of existing signal values
            - Removal of existing equipment
            - Installation of new equipment
            - Comparison and verification of new signal values
            - Equipment manual mode operation
            - Equipment auto mode operation
            - Equipment tuning
            - Operations staff takes “ownership”
            - Planning meeting
        f) Description of number of PCSS and Owner operations personnel that will be involved in the field and control room. These personnel must be dedicated to this project and must coordinate throughout the transition.
        g) I/O list grouped by transition order.

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h) Contact list including emergency contacts.

2) During transitions, coordination meetings should be held at the beginning and end of each day.
   a) Morning meetings shall be "Status and Go" meetings and.
   b) Afternoon meetings shall be "Planning" meetings to discuss transition issues and to plan the next day's work.
3) Below is a recommended MOPO activities outline, that will need to be verified and expanded:
   a) Before replacement of fiber optic cable or PLC, assure the tasks are scheduled with the Owner in advance at the "Status and Go" meeting each day, to assure all operations staff are aware of what equipment will be affected, the time frame for replacement, and assure all affected equipment is running in manual mode.
   b) Fiber Optic Cable. The current fiber optic cable backbone is a DH+ counter-rotating self-healing ring topology. The fiber will be added/replaced one section at a time, beginning between PLC-1 and PLC-X, and working its way around the ring. (The path taken will need to cause minimal impact on the plant process and operations staff.)
      - Disconnect the fiber strands from the PLC-1 and PLC-X patch panels.
      - Assure the existing DH+ ring is still operational.
      - Pull existing fiber out and new fiber into the existing conduit.
      - Terminate, test and connect new fiber to the patch panels and connect to the new Ethernet switches.
   c) Replacement of a PLC:
      - Investigate the existing program and identify all peer-to-peer communications data that will affect automatic system operations in other PLCs.
      - Discuss with the Owner whether the affected systems need to maintain operation or can be taken down and for how long. If required to remain in operation then continue below.
      - Reroute the peer-to-peer data from the new Ethernet capable PLC through the existing ControlLogix data concentrator in the PLC-1 cabinet.
      - The data will then route from the data concentrator, via DH+, to the existing PLCs.
      - Modify the existing PLC programs to use this new data location for its automatic operations.
   d) Once a PLC has been replaced:
      - Modify any peer-to-peer communications to receive data from the deriving PLC and not from the ControlLogix data concentrator.
      - Fully test operation of the plant equipment/systems in the PLC from the new HMI graphics.
   e) Once equipment is tested to the satisfaction of the Plant Supervisor, then allow operator access to that equipment on the new HMI graphics and discontinue access to that equipment on the existing HMI graphics. Alternately, clearly identify what equipment/systems are and are not available within each HMI graphic application at any given time.

3. Provide all required testing, training and documentation of the above equipment and services.

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C. Auxiliary and accessory devices necessary for system operation or performance, such as transducers, relays, signal amplifiers, intrinsic safety barriers, signal isolators, software, and drivers to interface with existing equipment or equipment provided by others under other Sections of these specifications, shall be included whether they are shown on the Drawings or not.

D. All equipment and installations shall satisfy applicable Federal, State and local codes.

E. Use the equipment, instrument, and loop numbering scheme shown on the Drawings and specifications in the development of the submittals. Do not deviate from or modify the numbering scheme without the Engineer's approval.

1.02 RELATED WORK

A. Instrumentation and Controls conduit systems are specified in Section 16110.

B. Instrumentation signal cable and alarm and status wiring are specified in Section 16120.

C. Relevant equipment sections in Division 11, 13, and 15.

1.03 SUBMITTALS

A. General Requirements:

1. Refer to Section 01300 for general submittal requirements.

2. Shop drawings shall demonstrate that the equipment and services to be furnished comply with the provisions of these specifications and shall provide a complete record of the equipment as manufactured and delivered.

3. Submittals shall be complete; giving equipment specifications, details of connections, wiring, ranges, installation requirements, and specific dimensions. Submittals consisting of only general sales literature shall not be acceptable.

4. Substitutions on functions or type of equipment specified shall not be acceptable unless specifically noted.

5. Separate or combined submittals shall be made for each submittal listed below.

B. Project Plan, Deviation List, and Schedule Submittal

1. Submit, within 45 calendar days after Notice to Proceed, a Project Plan. The Project Plan shall be submitted and approved before further submittals shall be accepted. The Project Plan shall, at a minimum, contain the following:
   a. Overview of the proposed control system describing the understanding of the project work, a preliminary system architecture drawing, interfaces to other systems, schedule, startup, and coordination.
   b. A discussion of startup, replacement of existing equipment with new, switchover, testing and training, and other construction tasks.
   c. Preliminary Maintenance of Plant Operations (MOPO) Plans for both WRF and SCADA systems, as specified herein.

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d. Preliminary list of HMI software, PLC software, and PLC hardware, including version numbers, solely to determine compliance with the requirements of the Contract Documents prior to beginning development of system programming. Review and approval of software and hardware systems as part of this Project Plan stage shall not relieve the PCSS of meeting all the functional and performance requirements of the system as specified herein. Substitution of manufacturer or model of these systems after the submittal is approved is not allowed without Engineer approval.
e. Project personnel and résumés, including the PCSS project manager, project engineer, and lead project technicians.
f. Sample formats of the shop drawings to be submitted and in conformance with the requirements of the Specifications. At a minimum include samples of panel fabrication drawings, loop, and I/O wiring diagrams.

2. Exceptions to the Specifications or Drawings shall be clearly defined in a Deviation List. The Deviation List shall consist of a paragraph by paragraph review of the Specifications indicating acceptance or any proposed deviations, the reason for exception, the exact nature of the exception and the proposed substitution so that an evaluation may be made by the Engineer. If no exceptions are taken to the specifications or drawings the PCSS shall make a statement as such. If there is no statement by the PCSS, then it is acknowledged that no exceptions are taken.

3. Project schedule shall be prepared in Gantt chart format clearly showing task linkages for all tasks and identifying critical path elements. PCSS schedule must be based on the General Contractor schedule and must meet all field installation, testing, and start-up milestones in that schedule. The project schedule shall illustrate I&C related major project milestones including the following:
   a. Schedule for all subsequent project submittals. Include the time required for Contractor submittal preparation, Engineer's review time, and a minimum of two complete review cycles.
   b. Proposed dates for all project coordination meetings.
   c. Hardware purchasing, fabrication, and assembly (following approval of related submittals).
   d. Software purchasing and configuration (following approval of related submittals).
   e. Shipment of instrument and control system equipment.
   f. Installation of instrument and control system equipment.
   g. Testing: Schedule for all testing. .
   h. Schedule for system cutover, startup, and/or going on-line for each major system. At a minimum include the schedule for each process controller and HMI server/workstation provided under this Contract.
   i. Schedule for all training, including submittal and approval of O&M manuals, factory training, and site training.

C. Input/Output (I/O) List Submittal

1. Submit, within 60 days after Notice to Proceed, a complete system Input/Output (I/O) address list for equipment connected to the control system under this Contract.

2. I/O list shall be based on the P&ID's, the Drawings, the design I/O list (if included), and requirements in the Specifications.

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3. The I/O list shall be submitted in both a Microsoft Excel readable electronic file format and an 8-1/2 inch by 11-inch hard copy.

4. The I/O list shall reflect all active and spare I/O points. Add points to accommodate spare I/O as required in the specifications.

5. The I/O list shall be arranged such that each control panel has a dedicated worksheet. At a minimum, I/O worksheet shall include the following information:
   a. TAG NUMBER(S): As indicated on the drawings, the identifier assigned to a device that performs a function in the control system. As part of this information, the loop number of the tag shall be broken out to allow for sorting by loop.
   b. DESCRIPTION: A description of the function of the device (text that includes signal source, control function, etc.) Include the text "Spare Points" for all I/O module points that are not connected to equipment.
   c. PHYSICAL LOCATION: The Control Panel designation of where the I/O point is wired to.
   d. Physical POINT ADDRESS: Rack, Slot, and Point (or Channel) assignment for each I/O point.
   e. I/O TYPE: use DO - Discrete Output, DI - Discrete Input, AO - Analog Output, AI - Analog Input, PI - Pulse Input, or PO – Pulse Output.
   f. RANGE/STATE: The range in engineering units corresponding to an analog 4-20 mA signal, or, the state at which the value of the discrete points are "1."
   g. ENGINEERING UNITS: The engineering units associated with the Analog I/O.
   h. ALARM LIMITS: Include alarm limits based on the control descriptions and the Drawings.
   i. P&ID – the P&ID or drawing where the I/O point appears on. Mark as "NA" (Not Applicable) if the I/O point is derived from a specification requirement and is not on the P&IDs.

6. The I/O list shall be sorted in order by:
   a. Physical location
   b. I/O Type
   c. Loop Number
   d. Device Tag

7. Once the I/O list is approved, the PLC I/O addresses shall not be modified without approval by the Engineer.

8. For I/O layout requirements, see Section 13311.

D. Field Instruments Submittal

1. Refer to Section 13340 for specific instrumentation submittal requirements.

E. Hardware and Software Packages Submittal

1. Refer to the sections below for specific Hardware and Software Packages submittal requirements
   a. 13310 I&C - Computer System Hardware
   b. 13311 I&C - PLC Hardware and Software
   c. 13315 I&C - HMI System Software

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d. 13320 I&C - Control and Data Network Equipment
e. 13321 I&C - Fiber Optic Cabling and Equipment
f. 13330 I&C - Control Panels and Panel Mounted Equipment
g. 13340 I&C – Field Instruments

2. For each hardware and software packages component specified in the sections above, submit a cover page that lists, at a minimum, date, specification number, product name, manufacturer, model number, Location(s), and power required. Preferred format for the cover page is ISA-TR20.00.01-2001 (updated in 2004-2006), general data sheet; however, other formats will be acceptable provided they contain all required information.

F. Panel Layout Drawings and Wiring Diagrams Submittal

1. Refer to Section 13330 for specific control panel submittal requirements.

G. Testing Submittals

1. Refer to Section 13302 for specific testing submittal requirements.

H. Training Submittals

1. Refer to Section 13303 for specific training submittal requirements.

I. Spares, Expendables, and Test Equipment Lists Submittal

1. Submit a list of, and descriptive literature for, spares, expendables, and test equipment.

2. Submit a list of, and descriptive literature for, additional spares, expendables, and test equipment recommended by the manufacturer.

3. Submit unit and total costs for the additional spare items specified or recommended for each subsystem.

J. Operations and Maintenance (O&M) Manuals

1. Submit in accordance with Section 01730. The cover and edge of each volume shall contain the information specified therein.

2. The operations and maintenance manuals shall, at a minimum, contain the following information:
   a. Table of Contents
      1) A Table of Contents shall be provided for the entire manual with the specific contents of each volume clearly listed. The complete Table of Contents shall appear in each volume.
   b. Instrument and Equipment Lists
      1) The following lists shall be developed in Microsoft Excel format and provided not only as a hardcopy in O&M but also electronically on a CD.
      2) An instrument list for all devices supplied including tag number, description, specification section and paragraph number, manufacturer, model number, serial number, range, span, location, manufacturer phone number, local supplier name,

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local supplier phone number, completion year replacement cost, and any other pertinent data.

3) An equipment list for all non-instrument devices supplied listing description, specification section and paragraph number, manufacturer, model number, serial number, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.

c. Equipment Operations and Maintenance Information
   1) ISA-TR20.00.01-2001(updated in 2004-2006) data sheets shall be provided for all field instruments. For non-field instrumentation devices, provide a cover page for each device, piece of equipment, and OEM software that lists date, specification number, product name, manufacturer, model number, Location(s), and power required. Preferred format for the cover page is ISA-TR20.00.01-2001(updated in 2004-2006), general data sheet; however, other formats will be acceptable provided they contain all required information
   2) Vendor O&M documentation for each device, piece of equipment, or OEM software shall be either new documentation written specifically for this project, or modified standard vendor documentation. All standard vendor documentation furnished shall have all portions that apply clearly indicated with arrows or circles. All portions that do not apply shall be neatly lined out or crossed out. Groups of pages that do not apply at all to the specific model supplied shall be removed.
   3) Provide the record documentation of the system audit as specified in the 13302 Testing section.
   4) Include the calibration forms developed as specified in the 13302 Testing section.

d. As-Built Drawings
   1) Complete as-built drawings, including all drawings and diagrams specified in this section under the "Submittals" section. These drawings shall include all termination points on all equipment the system is connected to, including terminal points of equipment not supplied by the PCSS.
   2) As built documentation shall include information from submittals, as described in this Specification, updated to reflect the as-built system. Any errors in or modifications to the system resulting from the Factory and/or Functional Acceptance Tests shall be incorporated in this documentation.

e. Original Licensed Software
   1) Submit original software diskettes or CD-ROMs of all software provided under this Contract. Submit original paper based and electronic documentation for all software provided. Submit license agreement information including serial numbers, license agreements, User Registration Numbers and related information. All software provided under this Contract shall be licensed to the Owner at the time of purchase. Provide media in software sleeves within O&M manual.

f. Electronic O&M Information
   1) In addition to the hard copy of O&M data, provide an electronic version of all equipment manuals and data sheets, along with any software back-up of configuration files, on CDROM or DVD. Electronic documents shall be supplied in Adobe Acrobat format.
   2) Provide electronic files for all custom-developed manuals including training manuals. Text shall be supplied in both Microsoft Office format and Adobe Acrobat format.

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3) Provide electronic files for all drawings produced. Drawings shall be in AutoCAD ".dwg" format and in Adobe Acrobat format. Drawings shall be provided using the AutoCAD eTransmit feature to bind external references, pen/line styles, fonts, and the drawing file into individual zip files.
4) Each computer system hardware device shall be backed up onto CDROM or DVD after Substantial Completion and shall be turned over to the Owner.
5) If specified in the training section, provide digital copies of all training videos. Videos shall be in a format that is readable by standard DVD players and by standard PC DVD drives. Format shall be a minimum of 800 by 600 pixels and shall include sound.

3. Refer to Section 13306 for additional requirements.

1.04 COORDINATION MEETINGS

A. Schedule the mandatory coordination meetings as described herein. The meetings shall be held at the Owner's designated location and shall include attendance by the Owner, the Engineer, the Contractor, and the PCSS's Project Engineer. Other Division 13 specifications may require additional meetings. Prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date. Meeting shall be scheduled a minimum of one week before the requested meeting date.

1. A project kickoff coordination meeting shall be held within two weeks after submitting the Project Plan. The purpose of the meeting shall be to discuss the PCSS's Project Plan, to summarize the PCSS's understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery deadline dates; provide a forum to coordinate hardware and software related issues; and request any additional information required from the Owner. The meeting will last up to one business day.

2. A submittal review coordination meeting shall be held after the Hardware, Panel Drawing, and Loop Drawing Submittal package has been reviewed by the Engineer and returned to the PCSS. The purpose of this meeting shall be to review comments made on the submittal package; to refine scheduled deadline dates; and coordinate equipment installation activities. The meeting will last up to one business day.

3. Maintenance of Plant Operations (MOPO) preliminary draft and final draft review meetings for both the Wastewater Reclamation Facility and for the Collection/Distribution System. The purpose of these meetings shall be to review the PCSS’s transition plans, planned down times, identify critical systems and system constraints, and identify operations staffing requirements.

4. Regular on-site meetings when the PCSS staff is at the plant site, including progress and MOPO meetings.

1.05 REFERENCE STANDARDS

A. Publications are referred to in the text by basic designation only. Where a date is given for reference standards, that edition shall be used. Where no date is given for reference standards, the latest edition in effect at the time of bid opening shall apply.

B. International Society of Automation (ISA)

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1. ISA S5.2 Binary Logic Diagrams for Process Operations

2. ISA S5.3 Graphic Symbols for Distributed Control/Shared Display Instrumentation Logic and Computer Systems.

3. ISA S5.4, Instrument Loop Diagrams.

4. ISA S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.

5. ISA RP60.3, Human Engineering for Control Centers

6. ISA RP60.6, Nameplates, Labels, and Tags for Control Centers

7. ISA-99, Industrial Automation and Control Systems Security

C. National Electrical Manufacturers Association (NEMA)

D. National Fire Protection Agency (NFPA)

1. NFPA 70, National Electrical Code (NEC).

2. NFPA 79, Industrial Control Equipment.

E. Underwriters Laboratories, Inc. (UL)

1. UL 508 - Industrial Control Equipment - for custom fabricated equipment

2. A nationally recognized testing laboratory, as approved by the Authority having jurisdiction, may substitute for UL listing on commercial off the shelf products.

1.06 QUALITY ASSURANCE

A. The Process Control System Supplier (PCSS) shall be a "systems integrator" regularly engaged in the design and the installation of instrumentation systems and their associated subsystems as they are applied to the municipal water and wastewater industry. For the purposes of this Specification Section, a "systems integrator" shall be interpreted to mean an organization that complies with all of the following criteria:

1. Employs personnel on this project who have successfully completed ISA or manufacturers training courses on general process instrumentation and configuration and implementation of the specific programmable controllers, computers, and software proposed for this project. Key personnel shall hold ISA CCST Level 1 certification or have a minimum of 10 years of verifiable plant startup experience. Key personnel shall include, as a minimum, the lead field technician.

2. Has successfully completed work of similar or greater complexity on at least three previous projects within the last five years. Successful completion shall be defined as a finished project completed on time, without any outstanding claims or litigation involving the PCSS. Potential references shall be for projects where the PCSS's contract was of similar size to this project.

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3. Has been actively engaged in the type of work specified in this Specification Section for a minimum of five years.

B. The PCSS shall maintain a permanent, fully staffed and equipped service facility within 200 miles of the project site with full time employees capable of designing, fabricating, installing, calibrating, and testing the systems specified herein. At a minimum, the PCSS shall be capable of responding to on-site problems within 12 hours of notice. Provide an on-site response within 4 hours of notification starting at two months before scheduled startup to two months after startup completion.

C. PCSS shall hold a valid UL-508 certification for their panel fabrication facility.

D. Actual installation of the instrumentation system need not be performed by the PCSS's employees; however, the PCSS as a minimum shall be responsible for the technical supervision of the installation by providing on site supervision to the installers of the various components.

E. The selected PCSS shall be one of the following:

1. Revere Control Systems
2240 Rocky Ridge Road
Birmingham, AL 35216
Attention: Mark Linn
Phone: 205-824-0004

2. C2i
5253 Oakdale Road
Smyrna, GA 30082
Attention: Mark Healey
Phone: 404-351-1085

3. Troy Systems
8215 Madison Blvd
Madison, AL 35758
Attention: Peggy Troy
Phone: 256-430-9890

F. Being listed in this specification does not relieve any potential PCSS from meeting the qualifications specified in this Section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage, and handling shall be in accordance with Section 01600.

B. Shipping Precautions

1. After completion of shop assembly, factory test and approval of all equipment, cabinets, panels and consoles shall be packed in protective crates and enclosed in heavy duty (5 mil) polyethylene envelopes or secured sheeting to provide protection from damage, dust and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving

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without removing protective covering. Boxed weights shall be shown on shipping tags together with instructions for unloading, transporting, storing and handling at the job site.

2. Manufacturer's special instructions for field handling, storage and installation required for protection, shall be securely attached to the packaging for each piece of equipment prior to shipment. The instructions shall be stored in resealable plastic bags or other means of protection.

3. None of the HMI control and monitoring equipment shall be shipped to the site until the control room areas comply with specified ambient temperature and humidity. Have qualified personnel accept the equipment on delivery and supervise unloading within the control room areas.

4. If any apparatus has been damaged, such damage shall be repaired at no additional cost to the owner.

1.08 NOMENCLATURE AND IDENTIFICATION

A. Field Instrument Tags

1. See Section 13340.

B. Panel Nameplates

1. See Section 13330.

1.09 WARRANTY

A. Provide warranty per Section 01740, Warranties and Bonds, and as specified herein.

1.10 MAINTENANCE CONTRACT

A. A written proposal for a maintenance contract executed by the PCSS shall be provided to the Owner for on-site preventive maintenance services related to the Instrumentation and Control system. The cost of this maintenance contract shall not be included in the Contract Price.

B. This proposal shall be provided within 30 days after final acceptance for the purpose of entering a contract for annual maintenance subsequent to the first year of maintenance. Standard per diem rates for providing breakdown service shall be set forth in the contract. Such rates shall be fair and reasonable and reflect the lowest rates offered to most favored customers. The fee quoted shall be firm for a minimum of 90 days from date of issue.

C. This maintenance contract shall include all labor, parts, and emergency calls providing on-site response within 24 hours, to provide complete system maintenance for a period of one year after the date of Substantial Completion of the system for all equipment and software provided as part of the PCSS scope of work.

D. Provide software updates throughout the maintenance contract period. Provide latest official released version for all software provided under this Contract. Owner shall have the latest software releases at the end of the maintenance contract period.

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E. The maintenance contract shall also include a minimum of 4 preventive maintenance visits by qualified service personnel of the Supplier who is familiar with the type of equipment provided for this project. Each preventive maintenance visit shall include routine adjustment, calibration, cleaning and lubrication of system equipment and verification of correct operation.

F. Visits to the sites to correct deficiencies under warranty shall not be included in this preventive maintenance service contract.

G. Emergency maintenance procedures or plant visits may coincide with a preventive maintenance visit, however, they shall not replace the work intended to be performed during a preventive maintenance visit. The Supplier shall have full responsibility for the system hardware preventive and corrective maintenance.

H. During the one-year maintenance period, observation of maintenance operations by plant personnel and the instruction of said personnel in the details of the maintenance work being performed, shall be provided.

1.11 PROJECT/SITE REQUIREMENTS

A. Environmental Requirements. Refer to Section 16000 and Electrical Drawings for specific environmental and hazardous area classifications.

B. Elevation: Equipment shall be designed to operate at the project ground elevation.

C. Temperature:

1. Outdoor areas' equipment shall operate between -30 to 50 C degrees ambient.

2. Equipment located in indoor locations shall operate between 10 to 35 C degrees ambient minimum.

3. Storage temperatures shall range from 0 to 50 C degrees ambient minimum.

4. Additional cooling or heating shall be furnished if required by the equipment as specified herein.

D. Relative Humidity. Air conditioned area equipment shall operate between 20 to 95 percent relative, non-condensing humidity. All other equipment shall operate between 5 to 100 percent relative, condensing humidity.

PART 2 PRODUCTS

2.01 GENERAL

A. All instrumentation and electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and epoxy or equal coating to prevent contamination by dust, moisture and fungus. The field mounted equipment and system components shall be designed for installation in dusty, humid and slightly corrosive service conditions.

B. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks unless otherwise noted. Fasteners for securing control panels and enclosures to

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walls and floors shall be either hot-dipped galvanized after fabrication or stainless steel. Provide stainless steel fasteners only in corrosive areas rated NEMA 4X on the Drawings or as defined under Section 16000. Provide minimum size anchor of 3/8-inch.

C. All indicators shall be linear in process units, unless otherwise noted. All transmitters shall be provided with indicators in process units, accurate to two percent or better.

D. All equipment, cabinets and devices furnished shall be heavy-duty type, designed for continuous industrial service. The system shall contain similar products of a single manufacturer, and shall consist of equipment models, which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

E. All electronic/digital equipment shall be provided with radio frequency interference protection.

F. Electrical

1. Equipment shall operate on a 60 Hertz alternating current power source at a nominal 120 volts, plus or minus 10 percent, except where specifically noted. Regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

2. With the exception for field device network connected devices, all electronic instrumentation shall utilize linear transmission signals of isolated 4 to 20 mA DC (milliampere direct current) capable of driving a load up to 750 ohms, unless specified otherwise. However, signals between instruments within the same panel or cabinet may be 1-5 VDC (volts direct current).

3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals will be allowed.

4. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless noted otherwise.

5. Switches and/or signals indicating an alarm, failure or upset condition shall be wired in a fail-safe manner. A fail-safe condition is an open circuit when in an alarm state.

6. Materials and equipment shall be UL approved whenever such approved equipment and materials are available.

7. All equipment furnished shall be designed and constructed so that in the event of power interruption, the systems specified herein shall go through an orderly shutdown with no loss of memory, and shall resume normal operation without manual resetting when power is restored, unless otherwise noted.

2.02 ELECTRICAL SURGE PROTECTION

A. General - Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines from lightning, utility, or the plant electrical system. The protection systems shall be such that the protective level shall

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not interfere with normal operation, but shall be lower than the instrument surge withstand level. Protection shall be maintenance free and self-restoring. Devices shall have a response time of less than 50 nanoseconds and be capable of handling a discharge surge current (at an 8x20µs impulse waveform) of at least 8 kA. Ground wires for all instrumentation device surge protectors shall be connected to a low resistance ground in accordance with Section 16660.

B. Provide protection of all analog signal (4-20 mA) circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and the control system end of the circuit. Protection devices located near the transmitter shall be mounted in a separate NEMA 4X enclosure or conduit mounted, and shall be Phoenix Contact PT Series, Edco SLAC series, or equal. Substitution of a single device to protect both 120 VAC and 4-20 mA wires to an instrument is acceptable. Protection devices in control panels shall be Phoenix Contact PT Series, EDCO, or equal.

C. Provide protection of all 120 VAC power feeds into control panels, instruments, and control room equipment. Surge arresters shall be Phoenix Contact "Mains-PlugTrab", EDCO HSP series, or equal.

D. Non-Fiber Based Data Highway or Communications Circuits – Provide protection on all communication and data highway circuits that leave a building or are routed external to a building. Circuit protection shall be provided at both ends of the line. Surge protection devices shall be Phoenix Contact PlugTrab Series, Transtector FSP Series, MTL Surge Technologies (Telematic) NP Series, Citel DLA series or MJ8 series, or equal.

E. RF Coaxial Cable – Provide protection on communication cables between radios and antennas, mounted either inside the panel, or in the wall of the enclosure in accordance with NEMA and UL standards. Surge protection devices shall be Citel P8AX series, Polyphaser, or equal.

F. Inductive Loads – Provide coil surge suppression devices, such as varistors or interposing relays, on all process controller outputs or switches rated 120 VA or less that drive solenoid, coil, or motor loads.

G. Telephone Circuits - At a minimum, provide Telephone Company approved line protection units for all telephone lines used for telemetry or SCADA system use under this Contract.

2.03 SPARE PARTS

A. All spare parts shall be wrapped in bubble wrap, sealed in a polyethylene bag complete with dehumidifier, then packed in cartons and labeled with indelible markings. Complete ordering information including manufacturer's contact information (address and phone number), part name, part number, part ordering information, and equipment name and number(s) for which the part is to be used shall be supplied with the required spare parts. The spare parts shall be delivered and stored in a location directed by the Owner or Engineer.

B. Furnish one of each type of installed surge protection devices.

C. Other spare parts are specified in each Section listed in paragraph 1.01.A.

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2.04 TEST EQUIPMENT

A. Provide all test equipment, instruction manuals, carrying/storage cases, unit battery charger, special tools, calibration fixtures, cord extenders, patch cords, test leads, and miscellaneous items for checking field operation of all supplied equipment.

B. All test equipment shall be wrapped in bubble wrap, sealed in a polyethylene bag with a dehumidifier, then packed in cartons and labeled with indelible markings. Complete ordering information including manufacturer's part number, and equipment name shall be supplied. The test equipment shall be delivered and stored in a location directed by the Engineer.

C. As a minimum, furnish the following test equipment:

1. One complete electronic process calibrator sets with rechargeable batteries, cases, spare fuses, test leads, and PC based software. Provide Altek 830, or equal.

2. One (1) portable digital multi-meter (DMM) with rechargeable battery and test leads, and carrying case, Fluke 289 Industrial Digital Multimeter, or equal. Combing the features of the electronic process calibrator and the DMM such as the Fluke 787 Process meter is acceptable.

3. One hand-held HART communicator, with case and all necessary accessories, Model 475 by Rosemount, or equal.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Instrumentation and accessory equipment shall be installed in accordance with manufacturer instructions. The indicated locations of equipment, transmitters, alarms and similar devices indicated are approximate only. Exact locations of all devices shall be as approved by the Engineer during construction. Obtain in the field, all information relevant to the placing of process control equipment and in case of interference with other work, proceed as directed by the ENGINEER and furnish all labor and materials necessary to complete the work in an approved manner at no additional cost to the Owner.

B. Provide brackets and hangers required for mounting of equipment.

C. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at only one ground point for each shield.

D. Investigate each space in the building through which equipment must pass to reach its final location. If necessary, ship material in sections sized to permit passing through restricted areas in the building. Provide on-site service to oversee the installation, the placing and location of system components, their connections to the process equipment panels, cabinets and devices, subject to the Engineer's approval. Certify that field wiring associated with the equipment is installed in accordance with best industry practice. coordinate work under this section with that of the electrical work specified under applicable Sections of Division 16.

E. Provide sunshades for equipment mounted outdoors in direct sunlight. Sunshades shall include standoffs to allow air circulation around the cabinet. Orient equipment outdoors to face

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northward, or as required, to minimize the impact of glare and ultraviolet exposure on digital displays.

3.02 TESTING

A. Refer to Section 13302.

3.03 TRAINING

A. Refer to Section 13303.

END OF SECTION

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SECTION 13311
PLC HARDWARE AND SOFTWARE

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section includes Programmable logic controllers for control of process equipment, process oriented machinery, and process systems.

1.02 RELATED WORK

A. Refer to Section 13300.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

C. Section 13330, Control Panels and Panel Equipment

1.03 SUBMITTALS

A. Refer to Section 13300.

B. Descriptive literature, bulletins, catalog cuts and Drawings for the equipment specified herein.

C. Complete bill of materials for the equipment.

D. Any deviation of the hardware or software systems from the preliminary submittal included in the Project Plan shall be described in detail.

E. Spare parts list.

1.04 REFERENCE STANDARDS

A. ASTM D999-91: Vibration

B. (CFR) Title 47, Part 18 (European EN 55011 (formerly CISPR 11))

C. CSA Certification Class I, Division 2, Group A, B, C, D Hazardous or non-hazardous locations

D. IEC 60068-2.1 Environmental testing – Part 2-1: Tests - Test A: Cold, 2.2 Environmental testing - Part 2: Tests. Tests B: Dry heat , 2.3, 2.6 Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal) and 2.27 Environmental testing. Part 2: Tests. Test Ea and guidance: Shock

E. IEC 61000 Electromagnetic compatibility (EMC) - Testing and measurement techniques

1. Part 4-2: Electrostatic discharge immunity test

2. Part 4-3: Radiated, radio-frequency, electromagnetic field immunity test

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3. Part 4-4: Electrical fast transient/burst immunity test

4. Part 4-5: Surge immunity test

5. Part 4-6: Immunity to conducted disturbances, induced by radio-frequency fields

F. IEC 61131-3: Programmable controllers - Part 3: Programming languages

G. IEC 801-3: RFI Immunity

H. IEC 801-5: Ground Continuity

I. IEC 801-2: Electrostatic Discharge

J. IEEE 472-1974/ANSI C37.90/90A-1974 (Surge Withstand) IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

K. MIL STD 461B CS02: RFI/EMI Susceptibility

L. NEMA Pub No ICS2-230.42: Showering Arc Test

M. NSTA Project 1A

N. UL 508 and CSA Standard C22.2 No. 142 (Isolation Voltages)

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer shall be capable of providing training, parts, and coordination of emergency maintenance and repairs.

B. To be considered for the work under this section, there shall be at least 3 firms located within 275 miles of the project site that have local staff actively installing, programming, supporting, and maintaining the submitted PLC for the PLC to be considered as an "or equal" to the listed manufacturers.

C. The programmable controller and all of the corresponding components within the family of controller products shall be manufactured by a company who regularly manufactures and services this type of equipment.

D. The manufacturer shall comply with ISO9001 standards for "Quality Systems- Model for Quality Assurance in Design/Development, Production, Installation, and Servicing".

E. The manufacturer shall provide complete technical support for all of the products. This shall include factory or on-site training, regional application centers, local or factory technical assistance, and a 24/7/365 technical support phone service.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver PLC components in packaging designed to prevent damage from static electricity and physical damage.

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B. Store PLC equipment according to manufacturer requirements. At a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. Protect PLCs from exposure to dirt, fumes, water, corrosive substances, and physical damage. Also, protect the PLC from all forms of electrical and magnetic energy that could reasonably cause damage.

1.07 NOMENCLATURE AND IDENTIFICATION DEFINITIONS

A. AI: Analog Input

B. AO: Analog Output

C. Fixed I/O: A PLC style consisting of a fixed number of I/O, a processor, and a power supply all in one enclosure. Some fixed PLCs have limited expansion ability.

D. CPU: Central Processing Unit

E. DI: Discrete Input

F. Distributed I/O: Hardware specially designed to function as Remote I/O.

G. DO: Discrete Output

H. HMI: Human-Machine Interface

I. I/O Input and/or Output

J. Modular: A PLC style consisting of cards that are assembled to comprise a complete unit. All I/O, CPU, and Power Supply are dedicated cards. Typically, these cards are inserted into a chassis.

K. Master/Slave: Communication between devices in which one device, the master, controls all communications. The other devices, the slaves, respond only when queried by the master. Typically used in a Remote I/O application.

L. Peer to Peer: Communication between two or more devices, typically PLC's, in which each device can control the communication exchange.

M. PID: Control action, proportional plus integral plus derivative.

N. PLC: Programmable Logic Controller

O. Remote I/O: I/O that is located remotely from the processor. Remote I/O can communicate over a variety of communication protocols and can use standard rack based I/O, or special Remote I/O hardware referred to as Distributed I/O.

P. SCADA: Supervisory Control and Data Acquisition

1.08 SPARE I/O

A. Each I/O drop and I/O location shall include at least 20 percent (minimum of four) points of each type (AI, AO, DI, and DO) for future use, regardless of whether any of those point types

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are used in that drop or location or not. The spares shall be the same type of I/O modules supplied.

B. Spare output points that require the use of an external relay shall be supplied with the external relay.

C. Regardless of the spare requirement, all installed unused points on all I/O modules shall be wired to terminal blocks in the order that they occur on the I/O modules. Unwired spares shall not be acceptable.

1.09 MANUFACTURER SUPPORT

A. Provide a manufacturer support agreement for products specified herein for a period of 12 months starting at final completion of the project. The cost of this manufacturer support agreement shall be included in the Contract Price. The support agreement shall be executed in the name of, and for the benefit of, the OWNER. At a minimum, this agreement shall provide the OWNER with:

1. 8 AM to 5 PM, 5 day per week manufacturer telephone support

2. Access to the manufacturer's technical support website

3. Software and firmware updates.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide Programmable Logic Controller equipment with the required memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points.

B. Processor Systems shall include processor, power supply, input/output modules, communication modules, redundancy modules, and remote interface modules as required to meet system requirements.

C. Furnish products listed and classified by Underwriters Laboratories (UL), CSA, or FM approval as suitable for purpose specified and indicated.

D. All equipment and devices furnished hereunder shall be designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production.

E. All equipment furnished shall be designed and constructed so that in the event of power interruption the systems shall go through an orderly shutdown with no loss of memory, and resume normal operation without manually resetting when power is restored.

F. The PLCs shall communicate between the operator workstation and field-mounted transducers, switches, controllers, and process actuators. Communications protocol shall be completely transparent to process operators at the Human Machine Interface (HMI).

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G. The PLC shall be capable of stand-alone operation in the event of failure of the communication link to the HMI subsystem.

H. Backup Processor Systems, if indicated on the drawings, shall consist of two chassis with power supplies, each containing a processor, redundancy module and communications module(s). Remote chassis shall be provided with communication modules to meet I/O and communication requirements.

I. Remote Input/Output Units shall include input/output modules, interface modules, communication modules, and power supply to meet system input and output requirements.

J. Agency and environmental specifications:

1. Electrical supply voltage to the PLC shall be 120 Vac, plus or minus "15 percent, 48-63Hz. PLC system power supplies shall be fused for overload protection.

2. Vibration: 3.5 mm Peak-to-Peak, 5-9 Hz: 1.0G, 9-150\Hz. The method of testing is to be based upon IEC 68-2-6 and JIS C 0911 standards for vibration. The system is to be operational during and after testing. Vibration Rating of 2.0G maximum peak acceleration for 10 to 500Hz. in accordance with at least one of the following:
   a. Installed rating: DIN rail mounted PLC: 10-57 Hz, amplitude 0.075 mm, acceleration 25-100 Hz, and
   b. Panel or plate mounted PLC: 2-25 Hz, amplitude 1.6mm, acceleration 25-200 Hz.
   c. In compliance with IEC 60068 and IEC 61131.

3. Shock: 15G, 11 msec. The method of testing is to be based upon IEC 68-2-27 and JIS C 0912 standards for shock. The system is to be operational during and after testing.

4. Temperature: All PLC hardware shall operate at an ambient temperature of 0 to +60 degrees C (+32 to +140 degrees F), with an storage ambient temperature rating of -40 to +85 degrees C (-40 to +185 degrees F).

5. Relative Humidity: The Programmable Controller hardware shall function continuously in the relative humidity range of 5 percent to 95 percent non-condensing.

6. Noise Immunity: The Programmable Controller system shall be designed and tested to operate in the high electrical noise environment of an industrial plant as governed by the following regulations: IEEE 472, IEC 801, MILSTD 461B, IEC 255-4, NEMA ICS 2-230.40, and ANSI/IEEE C-37.90A-1978.

7. Altitude:
   a. Operation: 0-6,500 feet
   b. Storage: 0-9,800 feet

8. Degree of protection: NEMA 1 (IP20)

9. All products shall have corrosion protection.

K. All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings indicating:

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1. Modules product type such as analog or digital

2. Modules catalog number

3. Modules major revision number

4. Modules minor revision number

5. Module manufacturer vendor

6. Module serial number

L. All necessary cables shall be included. All cables and connectors shall be as specified by the manufacturer. Cables shall be assembled and installed per the manufacturer recommendations.

2.02 MANUFACTURER

A. Provide all PLCs from a single manufacturer. If the PLC manufacturer has authorized third party vendors to provide modules that are compatible with their platforms, then products manufactured by these authorized third party vendors will be acceptable.

B. Provide the PLC system by the following:

1. Rockwell Automation Allen Bradley 1769 CompactLogix

2.03 CENTRAL PROCESSING UNIT (CPU) MODULE

A. General

1. The CPU shall be, at a minimum, a 16-bit microprocessor that provides system timing and is responsible for scheduling I/O updates, with no user programming required to ensure discrete or analog update. It shall execute user relay ladder logic programs, communicate with intelligent I/O modules, and perform on-line diagnostics. The CPU shall consist of a single module which solves application logic, stores the application program, stores numerical values related to the application processes and logic, and interfaces to the I/O.

2. The CPU shall sample all the discrete and analog inputs and outputs including internal coils and registers, and service special function modules every scan. The CPU shall process the I/O with user program(s) stored in memory, then control the outputs based on the results of the logic operation.

3. Supply the CPU with a battery-backed time of day clock and calendar.

4. The CPU family shall allow for user program transportability from one CPU model to another.

B. Diagnostics

1. The CPU shall perform on-line diagnostics that monitor the internal operation of the PLC. If a failure is detected, the CPU shall initiate system shutdown and fail-over. The following, at a minimum, shall be monitored: Memory failure, memory battery low, and

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general fault, communications port failure, scan time over run, I/O failure, and analog or special function I/O module failure.

2. All diagnostic information shall be accessible to the host communications interfaces and to the PLC program.

3. The PLC shall have indicators and on board status area to indicate the following conditions:
   a. CPU run
   b. CPU error or fault
   c. I/O failure or configuration fault.
   d. Status of Battery or back-up power module
   e. Communications indicator

C. Memory

1. The user program and data shall be contained in non-volatile battery backed memory of type CMOS RAM program memory or equivalent.

2. Memory Backup System: provide lithium battery backup or equivalent capable of retaining all memory for a minimum of three months and a Flash memory system capable of reloading program in the event of memory loss.
   a. Backup Storage: The backup battery or module shall be capable of being replaced without disrupting memory integrity. Provide a visual indication of low battery voltage or module error and an alarm bit in the PLC program.
   b. Flash or SD Memory Card: Memory card storage capacity shall be equal to or greater than processor memory capacity. Memory cards shall be installed in processors for factory testing.

3. The operating system shall be contained in non-volatile firmware. The memory containing the operating system shall be field updateable via a separate update tool.

D. Programming Environment

1. Programming port: The PLC shall utilize a serial USB or Ethernet port for programming.

2. On-Line programming: Application programs may be modified or stored while the CPU is running, with minimal impact on the scan time.

3. Online programming including runtime editing

4. IEC 61131-3 programming languages supported: Ladder logic, function block, sequential function chart, and structure text.

5. Supply all hardware and software necessary to program the CPU in these languages.

E. Communication Ports

1. The CPU shall be expandable and supplied with additional modules to support the required communication interfaces.

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F. Remote I/O Communications

1. The CPU shall be capable of communicating with up to 12 remote base locations at a combined distance of 2500 feet. The CPU shall automatically sample and update all local and remote I/O modules each scan cycle of the CPU.

2. The communication link between the CPU and any RIO chassis shall be as recommended by the PLC manufacturer. For racks located on a link of less than 2500 cable feet, the speed of the communications link shall be greater than 230K baud with RIO scan rate of less than 5 millisecond per RIO.

3. Diagnostic and equipment status information shall be available from each RIO.

4. It shall be possible to communicate with remote I/O racks or other PLCs via fiber optic cable.

5. The remote I/O system shall have available a remote input/output arrangement capable of operation at locations physically separated from the PLC CPU by up to 5,000 feet as detailed on the drawings.

6. Communication with the remote I/O arrangement shall be through cable as recommended by the PLC manufacturer and provided by the PLC system supplier under this specification section.

2.04 POWER SUPPLIES

A. The PLC shall have chassis mounted power supplies to power the chassis backplane, and provide power for the processor and applicable modules.

B. Power supplies shall have a clearly visible LED to indicate that the incoming power is acceptable and the output voltage is present.

C. Power supplies shall feature over-current and over-voltage protection and should be designed to operate in most industrial environments without the need for isolation transformers.

D. Power supplies shall be sized to accommodate the anticipated load plus 30%.

E. DC power supplies shall be capable of handling ripple up to 2.4V peak to peak.

F. AC Line Voltage rating of 85 to 265Vac, 47-63Hz

G. The power supplies shall allow for brown outs of at least 1/2 of a cycle, a harmonic rate of 10%, and will sustain continuous operation through momentary interruptions of AC line voltage of 10ms or less.

H. Automatically shut down the Programmable Controller system whenever its output power is detected as exceeding 125% of its rated power

I. Provide surge protection, isolation, and outage carry-over up to 2 cycles of the AC line

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J. Redundant power supplies will comply with all the requirements of non-redundant power supplies in addition to the features stated below.

1. The redundant power supplies shall be designed to share the current required by the chassis. In the event of a failure of one redundant power supply, the remaining supply will accommodate the entire load of the chassis without disruption to the chassis activity.

2. Provide a failsafe fuse that is not accessible by the customer

3. Provide a solid state relay connection to allow for failure annunciation when wired to an input module

4. Diagnostic LED status indicators for Power and redundancy

2.05 CHASSIS

A. Medium and large PLC models shall be chassis based.

B. All system and signal power to the CPU and support modules shall be distributed on the backplane. No interconnecting wiring between these modules via plug-terminated jumpers shall be acceptable.

C. All system modules, main and expansion chassis shall be designed to provide for free air flow convection cooling. No internal fans or other means of cooling, except heat sinks, shall be permitted.

D. All system modules including the processor shall be removable from the chassis or inserted in to the chassis while power is being supplied to the chassis without faulting the processor or damaging the modules.

E. Modules shall be designed to plug into a chassis and to be keyed to allow installation in only one direction. The design must prohibit upside down insertion of the modules as well as safeguard against the insertion of a module into the wrong slot or chassis via an electronic method for identifying a module. Electronic keying shall perform an electronic check to insure that the physical module is consistent with what was configured.

2.06 DISCRETE INPUT AND OUTPUT MODULES

A. General

1. Digital input and output modules shall provide ON/OFF detection and actuation.

2. The I/O count and type shall be as required to implement the functions specified plus an allowance for active spares, as noted below.

3. Modules shall be designed to be installed or removed while chassis power is applied.

4. Modules shall have indicators to display the status of communication, module health and input / output devices.

5. Each module shall have the following status indicators.

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a. The On/Off state of the field device.
b. The module's communication status.

B. Module Specifications (120VAC Input Module)

1. Nominal Input Voltage of 120VACc

2. On-State Current of 15mA @132V AC, 47-63Hz maximum

3. Maximum Off-State Voltage of 20V

4. Maximum Off-State Current of 2.5mA

5. Number of Points per Card: 16 maximum

C. Module Specification (120VAC Solid State Output Module)

1. Each triac type discrete output shall have an associated interposing relay located in the same control panel. 120 VAC power for relay outputs shall be provided from the associated motor starter control circuit (when used with motor starters) or other 120 VAC source (when I/O is not associated with a particular motor starter).

2. Output Voltage Range of 74-265V AC, 47-63Hz

3. Output Current Rating:
   a. Per Point – 0.5A maximum @ 30 degrees C; 0.25 A maximum @ 60 degrees C; Linear Derating
   b. Per Module - 4A maximum @ 30 degrees C; 2A maximum @ 60 degrees C; Linear Derating

4. Surge Current Per Point of 5A for 43ms each, repeatable every 2s @ 60 degrees C

5. Minimum Load Current of 10mA per point

6. Maximum On-State Voltage Drop of 1.5V peak @2.0A and 6V peak @load less than 50mA

7. Maximum Off-State Leakage of 2.5mA per point

8. Number of Points per Card: 16 maximum

D. Module Specifications (Individually Isolated, Relay Contact Output Module)

1. Output Voltage Range of 10-265V AC,, 47-63Hz ,5-125 VDC

2. Output Current Rating:
   a. Per Point – 2.5A maximum
   b. Per Module - 16A maximum

3. Power Rating (Steady State) of 250VA maximum for 125V ac inductive output

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4. Maximum Off-State Leakage of 0 mA per point

5. Configurable States
   a. Fault Per Point - Hold Last State, ON or OFF
   b. Program Mode Per Point - Hold Last State, ON or OFF

6. Number of Points per Card: 16 maximum

2.07 ANALOG INPUT AND OUTPUT MODULES

A. General

1. Analog input modules shall convert an analog signal that is connected to the module's screw terminals into a digital value. The digital value representing the magnitude of the analog signal shall be transmitted on the backplane. Analog output modules shall convert a digital value that is delivered to the module via the backplane into an analog signal on the module's screw terminals.

2. Modules shall be designed to be installed or removed while chassis power is applied.

3. Modules shall have indicators to display the status of communication, module health and input / output devices.

4. Each analog module shall provide both hardware and software indication when a module fault has occurred. Each module shall have an LED fault indicator and the programming software shall display the fault information.

5. Analog modules shall be software configurable through the I/O configuration portion of the programming software.

6. The following status shall be capable of being examined in ladder logic
   a. Module Fault Word – Provides fault summary reporting.
   b. Channel Fault Word – Provides under-range, over-range and communications fault reporting.
   c. Channel Status Words – Provides individual channel under-range and over-range fault reporting for process alarm, rate alarms and calibration faults.

7. The 24 VDC power for analog instrument loops shall be provided as a part of the system. The 24 VDC power supply shall be derived from the 120 VAC input power circuit to the PLC. The field side of the 24 VDC power sources(s) shall have individual or grouped (of logically associated circuits) fusing and be provided with a readily visible, labeled blown fuse indicator.

B. Differential Analog Input Module

1. Input Range of 0-20 mA or 4-20 mA

2. Resolution of approximately 16 bits across range

3. Input Impedance of Greater than 249 Ohms

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4. Overvoltage Protection: 8V ac/dc with on-board current resistor

5. Normal Mode Rejection of 60dB at 60Hz

6. Common Mode Noise Rejection of 120dB at 60Hz, 100dB at 50Hz

7. Isolation Voltage
   a. Channel to Ground/Chassis - 100% tested at 1000V dc minimum for 1s based on 250V ac.

8. Provide individual isolators, in addition to the surge suppression devices specified, in the control panels listed in Section 13330 for all signals that enter the panel from outside the building. Substitution of Isolated Analog cards to meet this requirement is acceptable. In addition, isolators shall be provided as shown on the drawings or for those signals that are coming from the following areas:

9. Number of Points per Card: 8 maximum

C. Isolated Analog Output Current Module

1. Output Current Range of 4 to 20 mA

2. Current Resolution of 12 bits across 20 mA

3. Open Circuit Detection – None

4. Output Overvoltage Protection - 24V ac/dc maximum

5. Output Short Circuit Protection – 20 mA or less (electronically limited)

6. Calibration Accuracy - Better than 0.1% of range from 4mA to 20 mA

7. Calibration Interval - 12 months typical

8. Number of Points per Card: 8 maximum

2.08 COMMUNICATION INTERFACES

A. The PLC will be capable of the following communication protocols as shown on the drawings:

1. 10BASE-T/100BASE-TX Ethernet communication.

2. Asynchronous serial link capable of communicating up to 19.2Kbps

B. When required, provide additional communications module(s) mounted in the chassis.

2.09 PLC SOFTWARE

A. Provide a PLC configuration and application development software package complete with documentation and disks. The PLC software package and associated licensing and/or activation

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shall be installed on the computers shown on the drawings and licensed to the appropriate personnel. Software and licenses shall be provided for each site location as listed below:

1. Franklin Wastewater Reclamation Facility

2. Franklin Collection/Distribution System

B. The software package shall allow on-line/off-line program development, annotation, monitoring, debugging, uploading, and downloading of programs to the PLCs.

C. All required hardware (including cables, cable adapters, etc.) for connection to PLCs shall be furnished.

D. All software licenses required to achieve the functionality described in the Specifications shall be provided.

E. The software package shall include a software license agreement allowing the Owner the right to use the software as required for any current or future modification, documentation, or development of the PLCs furnished for this project.

F. The software provided shall be capable of the following IEC 61131-3 functions:

1. Ladder logic.

2. Function block.

3. Sequential function chart.

4. Structure text.

G. In addition to the above editors, an add-on instruction editor shall work with any of the above-mentioned editors to create custom reusable function blocks. This software shall allow any of the derived function blocks to be modified on-line.

H. The software shall be Microsoft Windows-based and run on the supplied computers.

I. The software shall include a security feature to prevent unauthorized personnel from modifying and downloading the programs.

J. Provide an I/O simulator which allows the PLC application load program to be tested on a PC with simulated analog and digital inputs and outputs, allowing I/O testing and debugging to be performed in a safe, isolated environment without the need for running the PLC CPU and process I/O boards.

2.10 OPERATOR INTERFACE TERMINALS (OIT)

A. There is an existing Maple Systems OIT mounted on the Filter Complex control panel (PLC-8F) that is to remain and be reprogrammed to communicate with the new CompactLogix PLC.

B. Existing program will be provided by the Owner.

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2.11 SPARE PARTS

A. General requirements for spare parts are specified in Section 13300.

B. The following PLC spare parts shall be furnished at the WRF:

1. Processors: Provide one spare processor unit for each unique processor installed.

2. Memory Cards: Provide spares for each type of card installed.

3. I/O Cards: Provide two spares for each unique I/O module type installed.

4. Network interface, remote I/O, and communication modules: Provide one spare communication module for each unique communication module installed.

5. Specialty Modules: Provide one spare of each type of module identified.

6. PLC Power supplies: Provide one spare power supplies for each unique power supply installed.

7. Chassis: Provide spare chassis for each unique chassis installed.

8. Fixed PLCs: Provide spares for each unique type of PLC installed.

9. Miscellaneous components (including cables): Provide spares for each unique component installed.

C. The following PLC spare parts shall be furnished at the Collection/Distribution System:

1. Processors: Provide one spare processor unit for each unique processor installed.

2. Memory Cards: Provide spares for each type of card installed.

3. I/O Cards: Provide two spares for each unique I/O module type installed.

4. Network interface, remote I/O, and communication modules: Provide one spare communication module for each unique communication module installed.

5. Specialty Modules: Provide one spare of each type of module identified.

6. PLC Power supplies: Provide two spare power supplies for each unique power supply installed.

7. Chassis: Provide spare chassis for each unique chassis installed.

8. Fixed PLCs: Provide spares for each unique type of PLC installed.

9. Miscellaneous components (including cables): Provide spares for each unique component installed.

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PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Maintain area free of dirt and dust during and after installation of programmable controller products.

B. Anchor PLCs within enclosures as recommended by the PLC manufacturer.

C. Ventilation slots shall not be blocked, or obstructed by any means.

D. Examine areas, surfaces, and substrates to receive PLCs for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

E. Install in accordance with manufacturer's instructions.

F. Unload, unpack and transport equipment to prevent damage or loss.

G. Replace damaged components as directed by Engineer.

3.02 PANEL LAYOUT

A. Coordinate size and configuration of enclosure to meet project requirements. Drawings indicate maximum dimensions for PLCs, minimum clearances between PLCs, and adjacent surfaces and other items.

B. Comply with indicated maximum dimensions and clearances, or with PLC vendors required distances if they are greater than the distances indicated.

1. Provide spacing around PLC as required by the PLC manufacturer to insure adequate cooling. Insure that the air surrounding the PLC has been conditioned to maintain the required temperature and humidity range.

2. Wires entering and exiting PLC components shall be sized to comply with the PLC manufacturers requirements. Doors on all components shall be able to be fully closed when all the wires are installed.

3. For chassis mounted PLCs, no wiring, wire ducts, or other devices shall obstruct the removal of cards from the rack.

4. PLC lights, keys, communication ports, and memory card slots shall be accessible at all times. Lights shall be visible at all times when enclosure door is opened.

C. Control panel designer shall provide independent line fuses or circuit breakers, per the PLC manufacturer recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements.

D. Control panel designer shall insure that communication signals, 4-20mA signals (including those with embedded HART), are properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

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E. Each PLC (including all I/O) shall be powered from the UPS power conditioning system in Section 13330.

F. Where multiple sets of mechanical equipment are provided for process redundancy, arrange their field connections to I/O modules so that the failure of a single I/O module will not disable the redundant system. This applies to all I/O types. The acceptability of the I/O arrangement shall be at the discretion of the engineer.

G. Provide all required cables, cords, and connective devices for interface with other control system components.

END OF SECTION

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SECTION 13320
CONTROL AND DATA NETWORK EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish the labor and materials required to install and bring into operation the control and data network as shown on the Drawings and specified herein.

B. The network shall be capable of supporting communications between all servers, operator workstations, PLCs, RTUs, and other communication devices as shown on the system architecture block diagram(s). Furnish all necessary cables, face plates, connectors, modems, transceivers, repeaters, modules; splice kits, etc. required for a complete and operational network. The system architecture diagram(s) are for network understanding only. Some communication devices maybe required for network operation, which may not be explicitly shown on the Drawings. The system shall be designed to accommodate an increase of 100 percent of network nodes.

C. Furnish and install a complete Remote Input/Output (RIO) data highway capable of supporting communications between all PLCs as shown on the system architecture block diagram. Furnish all necessary cables, face plates, connectors, modems, transceivers, repeaters, modules; splice kits, etc. required for a complete and operational RIO data highway.

D. The control and data network shall include all nodes on the network. Communication between nodes may be via Ethernet, serial, fieldbus, or other method as shown on the drawings.

1.02 RELATED WORK

A. Refer to Division 16 specifications.

B. Refer to the E-sheets in the Drawing package.

C. Refer to Section 13300.

1.03 SUBMITTALS

A. Refer to Section 13300.

B. Descriptive literature, bulletins, catalog cuts and Drawings for the equipment specified herein.

C. Complete bill of materials for the equipment.

D. Spare parts list.

E. Complete system architecture diagram showing in schematic form, the interconnections between major hardware components including control centers, panels, power supplies, consoles, computer and peripheral devices, networking equipment, processors, I/O modules, local operator interfaces, process equipment vendor controllers, and like equipment. The system architecture shall be complete and shall depict all required cables, media type between components, network protocol used at each network level, details on connection requirements

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such as cable pin-outs, port numbers, and rack slot numbers. The intent of this specification requirement is to develop a diagram that is complete in every aspect to allow purchase of all required equipment by part number, and to allow a qualified technician to interconnect all equipment without having to refer to additional manuals or literature. Sheet size shall be 11"x17" and using more than one sheet is acceptable.

1.04 REFERENCE STANDARDS

A. Refer to Section 13300.

1.05 QUALITY ASSURANCE

A. Refer to Section 13300.

1.06 SYSTEM DESCRIPTION

A. WRF System Responsibility:

1. The Drawings and specifications depict a control and data network, which shall function as one unit. This network may be comprised of multiple communication protocols over various media.

2. The system backbone shall consist of 50/125 micro fiber optic cable in a self-healing ring formation. All PLC control panels shall contain communication components capable of supporting this technology. No PLC shall lose communication upon a single break in the fiber backbone.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 13300.

1.08 PROJECT/SITE REQUIREMENTS

A. Refer to Section 13300.

1.09 MAINTENANCE

A. Refer to Section 13300.

1.10 WARRANTY

A. Refer to Section 13300.

1.11 NOMENCLATURE AND IDENTIFICATION

A. Refer to Section 13300.

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PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

2.02 MANAGED ETHERNET SWITCHES

A. General

1. Provide a managed Ethernet switch(s) for connection to the control network backbone as shown in the Drawings and specified herein.

B. Physical Features

1. Fiber uplinks
   a. WRF: 2 x 100/1000 FX ports with ST connectors, minimum
   b. Collection/Distribution System: None

2. Copper ports
   a. WRF: 6 x 10/100 TX RJ45 ports, minimum
   b. Collection/Distribution System: 4 x 10/100 TX RJ45 ports, minimum

3. Operating temperature: 32 to 130 degrees F

4. Power: 24 VDC redundant power supply inputs

5. Enclosure: Metal case, DIN-rail mountable

6. Rating: UL Class 1, Division 2 Groups A, B, C, and D

C. Network Features

1. Fault tolerant for use in a ring topology if shown on drawings. The switch shall be able to detect a blocked port and redirect data flow in the opposite direction within 30ms.

2. Full duplex on all port

3. Auto negotiation and manual configurable speed and duplex

4. Wire speed switching fabric

5. IEEE 802.1w RSTP

6. IGMP snooping

7. IGMP filtering

8. Configuration password protected

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9. Configuration backup capability required

10. SNMP V3

11. Lock port function for blocking unauthorized access based on MAC address.

D. Acceptable Manufacturers

1. Hirschmann

2. N-Tron

3. Moxa

4. Or equal

2.03 ETHERNET MEDIA CONVERTERS

A. General

1. Provide Ethernet media converter(s) as shown in the Drawings and specified herein.

B. Physical Features

1. RJ45 ports: 10/100BaseTX to 100BaseTX

2. Fiber uplinks: 100BaseTX to 100BaseFX (ST connectors)

3. Fiber optics: Multi- or single-mode capability as shown in the Drawings

4. Operating temperature: 32 to 130 degrees f

5. Power: 24 VDC

6. Enclosure: DIN-rail mountable

C. Acceptable Manufacturers

1. Phoenix Contact

2. N-Tron

3. Or Equal

2.04 WIRES AND CONNECTORS

A. Ethernet 10/100/1000 BASE-T/TX Cable.

1. The unshielded twisted pair cable shall be Category 6 standard or better: designed for use with a high speed (10/100/1000 Mbps) Ethernet 10/100/1000 BASE-T/TX communications network. The twisted pair cable shall have a nominal impedance 100

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ohms at one MHz, a maximum attenuation of 8 dB per 1000 feet at one MHz. The twisted pair cable must have frequency tested up to 250 MHz or more. The twisted pair cable shall be plenum rated and shall have a minimum of four 23 AWG solid copper conductor pairs. All 10/100/1000 BASE-T/TX (RJ-45) terminations on the twisted pair cable shall be done in a professional and workman like manner. Terminations shall provide for proper strain relief on the cable jacket. Strain relief on the wire and/or wire insulation shall not be acceptable.

B. RIO Data Highway Cable

1. The RIO data highway cable shall be plenum rated cable of the type as recommended by the PLC manufacturer. All terminations shall be done in a professional and workman like manner. Terminations shall provide for proper strain relief on the cable jacket. Strain relief on the wire and/or wire insulation shall not be acceptable.

2.05 SPARE PARTS

A. General requirements for spare parts are specified in Section 13300.

B. The following Network and Communications System spare parts shall be furnished at the WRF:

1. One switch of each type provided.

2. One media converter of each type provided

3. Manufacturer's cables - one of each type installed.

4. Five-10ft CAT 6 cables with connectors installed

C. The following Network and Communications System spare parts shall be furnished at the Collection/Distribution System:

1. Two Ethernet radios of each type provided.

2. One switch of each type provided.

3. One media converter of each type provided

4. Manufacturer's cables - one of each type installed.

PART 3 EXECUTION

Refer to Section 13300 and 13302.

END OF SECTION

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SECTION 13321
FIBER OPTIC CABLING AND EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Work of this Section includes providing a fiber optic communications infrastructure including, but not limited to, fiber optic cable (FOC), patch panels, terminations, testing, and implementation.

B. The Work includes testing individual fiber cables installed under this Contract, and testing a completed fiber optic communications network.

1.02 RELATED WORK

A. Delivery, Storage and Handling in Section 01600.

B. Process Instrumentation and Control System in Section 13300.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Sections 01300 and 01730, the following:

1. Catalog Data: Catalog data on fiber-optic cable, termination devices, patch panels, breakout enclosures, splice kits, pigtails, and fan-outs where applicable. Product data sheets shall include the manufacturer's name and catalog number for each item, the manufacturer's descriptive literature, catalog cuts, and any power supply requirements.

2. Certification of compliance in writing stating the fiber optic cable, anticipated layout, and components are compatible, acceptable for use, and in compliance with these specifications.

3. Detailed bill of materials for fiber-optic cable, terminations, patch panels, breakout enclosures, splice kits, connectors, pigtails, and fan-outs.

4. Drawings indicating the locations of all patch panels, termination points, or breakout enclosures.

5. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.

B. Provide four samples of each type of cable, splice, and connector termination kit. Four samples of a completed example of each type of splice and connector termination shall be submitted.

C. The Fiber Optic System Supplier shall provide a fiber optic power budget for each cable run in excess of 1000 feet. The budget shall include transmitter power, receiver sensitivity, connector losses, cable losses, and a 3db-aging margin. Fiber optic transmission line shall maintain a minimum of 10db safety margin.

D. Training plan and schedule for fiber optic cable termination training.

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E. Test reports.

F. O&M manuals.

1.04 REFERENCE STANDARDS

A. The optical fiber cable shall conform to the latest issue of the following standards documents, which are incorporated by reference into this specification:

1. EIA-455: Standard Fiber Optic Test Procedures (FOTPs) Devices.

2. EIA-598-A: Standard Colors for Color Identification and Coding.

3. MIL-202: Test Methods for Electronic and Electrical Component Parts.

4. MIL-454: Standard General Requirements for Electronic Equipment.

5. MIL-810: Environmental Test Methods and Engineering Guidelines.

6. EIA-568-B.3: Commercial Building Telecommunications Cabling Standard: Optical Fiber Cabling Components.

7. ICEA 5-83-696: Fiber Optic Premises Distribution Cable (Indoor/Outdoor).

8. National Electrical Code (NEC) Article 770.

9. UL 1581 VW-1 - Vertical Tray Cable Flame Test.

10. UL 1666 - UL Standard for Safety Test for Flame-Propagation Height of Electrical and Optical-Fiber Cables Installed in Vertical Shafts.

11. NFPA 262 – Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use IN Air-Handling Spaces.

12. IEEE Standard 383 - Flame Retardancy.

13. DOD-STD-1678.

14. National Electrical Manufacturers Association (NEMA).

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

B. All fiber optical cables shall be constructed in accordance with EIA-455, and 100 percent of all optical fibers and jacketing shall meet or exceed the requirements contained in this specification.

1.05 QUALITY ASSURANCE

A. The cable manufacturer shall be ISO9001 certified and registered.

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B. The fiber optic cabling system materials furnished under this Section shall be provided by Fiber Optic Suppliers who have been providing these types of materials for the past three years. The Fiber Optic Suppliers shall provide personnel capable of providing technical assistance during installation.

C. The installation of fiber optic cabling system materials furnished under this Section shall be performed by an installation Contractor who has been installing these types of materials and systems for the past three years.

D. Supplier must furnish five working installation references.

E. The Engineer shall determine whether a product is an Equal based upon the information listed herein and the manufacturer's data sheets regarding the models specified. Alternate equipment must meet the criteria listed herein and any additional information in the manufacturer's data sheets in order to be accepted as an Equal.

1.06 DELIVERY, STORAGE, AND HANDLING

A. The cable shall be packaged in cartons and/or wound on spools or reels. Each package shall contain only one continuous length of cable. The packaging shall be constructed so as to prevent damage to the cable during shipping and handling.

B. When the length of an order requires a large wooden reel, the cable will be covered with a three-layer laminated protective material. The outer end of the cable shall be securely fastened to the reel head so as to prevent the cable from becoming loose in transit. The inner end of the cable shall project into a slot in the side of the reel or into housing on the inner slot of the drum, in such a manner and with sufficient length to make it available for testing.

C. Test tails shall be at least two meters long. The inner end shall be fastened so as to prevent the cable from becoming loose during shipping and installation. Reels shall be permanently marked with an identification number that can be used by the manufacturer to trace the manufacturing history of the cable and fiber.

D. Wooden reels shall be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the cable on the reel.

E. All fiber optic cables shall be attenuated tested. The attenuation of each fiber shall be provided with each cable reel by the manufacturer.

F. The attenuation shall be measured at 1310 nm and 1550 nm for single-mode fibers and 850nm and 1300nm for multimode fiber cables after received on site. The manufacturer shall submit the test results prior to installation of the cable.

G. Packaging

1. The completed cable shall be packaged for shipment on non-returnable wooden reels. It is the responsibility of the Contractor to determine all required cable lengths.

2. Top and bottom ends of the cable shall be available for testing.

3. Both ends of the cable shall be sealed to prevent the ingress of moisture.

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4. Each reel shall have a weatherproof reel tag attached identifying the reel and cable. The reel tag shall include the following information:
   a. Cable Number Gross Weight.
   b. Shipped Cable Length in Meters.
   c. Product Number.
   d. Date Cable was Tested.
   e. Cable Length Markings Item Number.

H. Each cable shall be accompanied by a cable data sheet.

1.07 SPARE PARTS AND TEST EQUIPMENT

A. Spare Parts

1. Provide a minimum five percent spares of ST connectors and dust covers, but not less than 20 spare ST style connectors and 40 dust covers.

2. Provide a minimum five percent spare 36" spare multimode patch cables with connectors (both ends) terminated, but not less than ten 36" spare multimode patch cables with connectors (both ends) terminated.

B. Test Equipment and Tools

1. None.

PART 2 PRODUCTS

2.01 GENERAL MATERIALS

A. Cabinets: cabinets shall be provided as indicated on the contract Drawings.

B. Provide tight buffered cables that are not gel filled and are suitable for indoor/outdoor applications. These cables shall be flame retardant for indoor applications and water and fungus resistant for outdoor applications.

C. Optical Fiber Characteristics

1. All fibers in the cable must be usable fibers and meet required specifications.

2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design.

3. Multi-mode: Provide multimode, optical glass fiber compatible with LED or laser based transmission systems .

D. Manufacturers

1. Corning Cable Systems Corp.

2. CommScope.

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3. Belden Cable.

4. Or equal.

2.02 STANDARD 50/125 µM FIBER

A. The multimode fiber utilized in the optical fiber cable shall meet EIA/TIA-492AAAB, "Detail Specification for 50-µm Core Diameter/125-µm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers".

1. Geometry

Core Diameter (µm)	50.0 ± 3.0
Core Non-Circularity	≤ 5 %
Cladding Diameter (µm)	125.0 ± 2.0
Cladding Non-Circularity	≤ 1.0 %
Core-to-Cladding Concentricity (µm)	≤ 1.5
Coating Diameter (µm)	245 ± 5
Colored Fiber Nominal Diameter (µm)	253 - 259

2. Optical

Cabled Fiber Attenuation (dB/km) 850 nm 1300 nm	 ≤ 3.5 ≤ 1.5
Point discontinuity (dB) 850 nm 1300 nm	 ≤ 0.2 ≤ 0.2
Cabled Effective Modal Bandwidth[1)] (MHz•km) 850 nm	 ≥ 510
IEEE 802.3 GbE Distance (m) 1000BASE-SX Window (850 nm) 1000BASE-LX Window (1300 nm)	 up to 600 up to 600
OFL Bandwidth (MHz•km) 850 nm 1300 nm	 ≥ 500 ≥ 500
Numerical Aperture	0.200 ± 0.015

[1)]As predicted by RML BW, per TIA/EIA 455-204 and IEC 60793-1-41, for intermediate performance laser based systems (up to 1 Gb/s).

2.03 FIBER OPTIC INTERCONNECT CABLE

A. Tight-Buffered fiber surrounded by aramid yarn strength members and flame-retardant jacket.

B. Cable Specifications

1. Fiber Count: Single or duplex type as required.

2. National Electric Code OFNR designation.

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3. Crush Resistance: 20 lbf/in (35 N/cm)

4. Operating Temperature: -20 to +70 degrees C

C. Fiber Specification Parameters

1. Required Fiber Grade - Maximum Individual Fiber Attenuation.

2. Single-mode only: The maximum dispersion shall be no greater than 3.2 ps/(nm-km) from 1285 nm to 1330 nm, and shall be less than 18 ps/(nm-km) at 1550 nm.

3. The fiber manufacturer shall proof-test 100 percent of the optical fiber to a minimum load of 100 kpsi.

2.04 LOOSE TUBE FIBER OPTIC CABLE (INDOOR/OUTDOOR)

A. Cable shall be flame-retardant, UV stabilized, fully water blocked with dielectric central member for use in indoor/outdoor applications. The buffer tubes shall be gel-free. Each buffer tube shall contain a water-swellable yarn for water-blocking protection. Cable manufacturer shall have a minimum of 20 years in manufacturing optical fiber cable in order to demonstrate reliable field performance. Cable and fiber manufacturer shall be the same company to ensure long-term reliability of the cabled fiber and to ensure the availability of fully integrated technical support. Cable shall be suitable for installation in duct, aerial, and riser environments. Cable shall meet UL OFNR specifications and not require transition splicing upon building entry in order to meet fire codes.

B. Optical fibers shall be placed inside a buffer tube.

C. Each buffer tube shall contain up to 12 fibers.

D. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

E. Buffer tubes shall be kink-resistant within the specified minimum bend radius.

F. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

G. The central anti-buckling member shall consist of a glass-reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

H. The cable core shall contain a water-blocking material. The water-blocking material shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional non-toxic solvents. Cable shall contain water-blocking threads between tubes.

I. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

J. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns.

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K. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.

L. All dielectric cables (with no armoring) shall be sheathed with medium density polyethylene (MDPE). The minimum normal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water-blocking material. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

2.05 CABLE CONSTRUCTION

A. Riser Cables

1. Riser cables up to 24 fibers: In cables with more than one fiber, the fibers shall be stranded around a dielectric member and surrounded by layered aramid yarns. The aramid yarns shall serve as the tensile strength member of the cable. A ripcord may be applied between the aramid yarns and the outer jacket to facilitate jacket removal. The outer jacket shall be extruded over the aramid yarns for physical and environmental protection.

2. Riser cables with more than 24 fibers: The buffered fibers shall be grouped into six fiber subunits. In each subunit, the individual fibers shall be stranded around a dielectric central member and surrounded by layered aramid yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. The subunit jacket shall be extruded over the aramid yarns for additional physical and environmental protection. The subunits shall be stranded around a dielectric central member. A ripcord shall be inserted beneath the outer jacket to facilitate jacket removal. The outer jacket shall be extruded around the units for physical and environmental protection.

B. Plenum Cables

1. Plenum cables up to 24 fibers: The fibers shall be stranded around a dielectric member and surrounded by layered aramid yarns. The aramid yarns shall serve as the tensile strength member of the cable. A ripcord may be applied between the aramid yarns and the outer jacket to facilitate jacket removal. The outer jacket shall be extruded over the aramid yarns for physical and environmental protection.

2. Plenum cables with 24 to 72 fibers: The buffered fibers shall be grouped into six fiber subunits. In each subunit, the individual fibers shall be stranded around a dielectric central member and surrounded by layered aramid yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. The subunit jacket shall be extruded over the aramid yarns for additional physical and environmental protection. The subunits shall be stranded around a dielectric central member. A ripcord shall be inserted beneath the outer jacket to facilitate jacket removal. The outer jacket shall be extruded around the units for physical and environmental protection.

3. Plenum cables with more than 72 fibers: The buffered fibers shall be grouped into twelve fiber subunits. In each subunit, the individual fibers shall be stranded around a dielectric central member and surrounded by layered aramid yarns. A ripcord shall be incorporated in the subunit design to facilitate access to the individual fibers. The subunit jacket shall be extruded over the aramid yarns for additional physical and environmental protection. The subunits shall be stranded around a dielectric central member. A ripcord shall be inserted

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beneath the outer jacket to facilitate jacket removal. The outer jacket shall be extruded around the units for physical and environmental protection.

C. The strength member shall be a high modulus aramid yarn. The aramid yarns shall be helically stranded around the buffered fibers. Non-toxic, non-irritant talc shall be applied to the yarn to allow the yarns to be easily separated from the fibers and the jacket.

D. Cable Jacket

1. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.

2. The cable and subunit jacket color shall be orange for cables containing multimode fibers.

3. The cable and subunit jacket color shall be yellow for cables containing single-mode fibers.

4. For cables with more than two fibers, the cable jacket shall be designed for easy removal without damage to the optical fibers by incorporating a ripcord under each cable jacket. Non-toxic, non-irritant talc shall be applied to the aramid yarns to allow the yarns to be easily separated from the fibers and the jacket.

5. The nominal thickness of the cable outer jacket shall be sufficient to provide adequate cable protection while meeting the mechanical, flammability, low smoke, and environmental test requirements of this document over the life of the cable.

E. The cable shall be all-dielectric.

2.06 CABLE IDENTIFICATION

A. The individual fibers shall be color coded for identification. The optical fiber color coding shall be in accordance with EIA/TIA-598, "Color Coding of Fiber Optic Cables." The coloring material shall be stable over the temperature range of the cable, shall not be susceptible to migration, and shall not affect the transmission characteristics of the optical fibers. Color coded buffered fibers shall not adhere to one another. When fibers are grouped into individual units, each unit shall be numbered in the unit jacket for identification. The number shall be repeated at regular intervals.

B. The outer cable jacket shall be marked with the manufacturer's name or UL file number, date of manufacture, fiber type, flame rating, UL symbol, and sequential length markings every two feet. The markings shall be in contrasting color to the cable jacket.

2.07 CABLE TESTING REQUIREMENTS

A. Fiber cables shall be tested in accordance with the following industry standard (EIA-455) tests:

1. FOTP-41, Compressive Loading Resistance Test.

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2. FOTP-104, Fiber Optic Cable Cyclic Flexing Test.

3. FOTP-25, Repeated Impact Testing.

4. FOTP-33, Fiber Optic Cable Tensile Loading and Bending Test.

5. FOTP-85, Fiber Optic Cable Twist Test.

6. FOTP-181, Lightning Damage Susceptibility Test.

7. FOTP-3, Procedure to Measure Temperature Cycling Effects on Optical Fibers, Cables, and other Passive Fiber Optic Components.

8. FOTP-82, Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable.

9. FOTP-37, Low or High Temperature Bend Test for Fiber Optic Cable.

10. FOTP-98, External Freezing Test.

11. FOTP-27, Fiber Diameter Measurements.

12. FOTP-28, Measurement of Dynamic Tensile Strength.

13. FOTP-34, Interconnection Device Insertion Loss Test.

14. FOTP-89, Cable Jacket Elongation and Tensile Strength Test.

B. The Contractor shall submit laboratory test reports on representative samples of similar cable design to demonstrate compliance prior to cable installation.

2.08 FIBER CABLE TERMINATIONS, CONNECTORS, AND CABLE ASSEMBLIES

A. Pigtail Splicing

1. For termination of fiber cables at a termination or connector panel (patch panel), with one end of a piece of cable preconnectorized and the other end unterminated for splicing to the cable that needs to be terminated. Splicing and connectors shall meet the requirements listed in this Section.

2. A splice/termination tray shall house the splices and serve to fully protect excess lengths of loose tube fibers from exposure. Splice tray shall be compatible with the selected patch panel and installed for easy access to the spliced cable sections.

3. Pigtail assemblies shall match fiber cable type and model and shall be as manufactured by Corning Cable Systems or equal.

B. Buffer Tube Fan-Out Kits

1. Individual fibers within a loose tube cable with 250 µm coated fibers shall use a fan-out kit to maintain flexibility and ease of handling fibers within a termination cabinet. Fan-out kits shall be installed in the patch panel enclosures to transition the loose tube fibers to

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ruggedized tight-buffered fiber pigtail cables. Optical fusion splices shall connect the loose tube fibers to the tight-buffered pigtail cables. The optical splice loss shall comply with the specifications for optical splices. Splice protection sleeves shall be employed on all splices to protect the splices.

2. The tight-buffered pigtails shall be factory-preconnectorized with STTM connectors as specified.

C. Connectors (Cable Assemblies)

1. The fiber optic communications system shall utilize stainless steel ST style connectors for all fiber optic connections. SC style connectors will be acceptable only if ST style connectors are not compatible with the equipment being provided. The connectors shall be designed for use with 50/125 micron cable. Each connector shall cause a maximum signal attenuation of 1.6 dB.

2. Factory-Installed Connectors: All interconnect cable assemblies shall have connectors installed at the factory. The connectors shall provide tight-fitting termination to the cladding and buffer coating. Epoxy-based or "hot melt "adhesives shall be used to bond the fiber and buffer to the connector ferrule and body prior to polishing the endface.

3. Field-Installed Connectors: Type ST design with ceramic or polymer ferrule and strain relief boot. The connector installation shall not require the use of epoxies, adhesives or ovens. The connector shall be installable upon 900 µm buffered fiber in one minute or less and upon 2.9 mm jacketed cable in three minutes or less total time. The connector shall contain a mechanical splice and have a tool kit available to aid in assembly. The installation tools used to terminate the connector shall be able to terminate other small-form-factor and single-fiber UniCam connector designs. The connector shall not require end-face polishing in the field. The connector shall have a factory polished optical fiber stub in the connector ferrule that is bonded in the ferrule micro hole. Ferrule material shall be available in ceramic or polymer. Connector specifications shall be as follows:
   a. Insertion loss (typical): 0.3 dB
   b. Durability (mating cycles): 500 (minimum)
   c. Repeatability: Less than 0.2 dB
   d. Operating Temperature: 0 to plus 60 degrees C]

4. After termination with connectors, the fiber ends must be visually inspected at a magnification of not less than 100 power for multimode and 200x for single mode to check for cracks or pits in the endface of the fiber.

5. Connectors shall have a maximum allowable connection loss of 0.3 dB per mated pair, as measured per EIA-455-34. No index-matching gel is to be used; dry interfaces only.

6. Each connector shall be of the industry standard ST type compatible; designed for single-mode and multimode tolerances; shall meet or exceed the applicable provisions of EIA-455-5, 455-2A, and 455-34; and shall be capable of 100 repeated ratings with a maximum loss increase of 0.1 dB. Connectors shall incorporate a key-way design and shall have a Zirconia ceramic ferrule. Connector bodies and couplings shall be made of corrosion-resistant and oxidation-resistant materials such as nickel-plated zinc, designed to operate in humid environments without degradation of surface finishes. Connectors shall be capable of operating in a range of -40 to 80 degrees C.

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7. Manufacturers
   a. Corning Cable Systems, Hickory, NC
   b. AMP, Inc., Harrisburg, PA
   c. 3M Telecom Systems Group, Austin, TX or equal.

D. Fiber Optic Patch Cables

1. Fiber optic patch cable shall be two-fiber zipcord 50/125 core/clad micron multimode riser rated cable.

2. Installation of patch cables shall include all spares and observe the minimum fiber bend radius and strain relief.

2.09 FIBER OPTIC TERMINATION PATCH PANELS

A. General

1. Patch panels shall be suitable for wall mounting, comprised of internal mounting plate, cable holders, slack cable take up/organizer blocks, patch block with connectors, and ground lugs as indicated. Panels shall be NEMA 4X, 316 stainless steel construction for outdoors; and NEMA 12, 316 stainless steel or fiberglass for indoor use. Patch panels shall be suitable for multimode system operation at 800 and 1300 nanometers. Patch panels shall be suitable for ST or LC connectors. The patch panels shall be sized to handle the number of fibers as required. All fibers shall be terminated in the patch panel.

2. Where shown on the plans or in the related specification Sections, the fiber optic cable shall terminate inside a communications cabinet on a termination patch panel. All fiber sub-cables within the exposed buffer tube shall be terminated with fan-out kits with preconnectorized pigtails. The patch panel shall have a fiber capacity equal to the total number of fibers (connected and spare) for all cables to be connected.

3. Unused buffer tubes shall be uncut and looped within the patch panel for continuous routing of the fiber buffer tube within the cable assembly.

4. Patch panels shall be designed for either rack mounting on a standard equipment rack or housed in an enclosure for direct wall mounting. The patch panel shall contain "ST" type bayonet or LC couplings. All unused couplings shall have protective dust covers. All panels shall be furnished with locking doors.

5. Factory-terminated, tight-buffered, aramid-reinforced fiber optic jumper assemblies or interconnect cables, standard 3.0-mm O.D., shall connect the optical cable terminations to the patch panel couplings.

6. The termination patch panel shall be equipped with a suitable means for routing and securing of cables, and shall provide a suitable means of protection for the mounted fiber connectors to prevent damage to fibers and connectors during all regular operation and maintenance functions. All cables shall be provided with strain relief. Bend diameters on cable fibers and jumpers must be greater than four inches at all times to ensure optical and mechanical integrity of the optical fibers.

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7. Termination panels shall be equipped with splice trays (where applicable) and holders for pigtail and through fiber splicing.

8. Termination panels shall be provided with all hardware, options, and accessories to provide for a complete installation of the fiber optic system.

9. Panels shall be as manufactured by Corning Cable Systems LANscape or equal.

B. Wall/Panel Mount Fiber Distribution Center (WDC)

1. The field-mounted fiber termination enclosures shall be supplied with a Wall Mount Fiber Distribution Center (WDC) capable of 48 ST fiber termination points. The distribution center shall be panel-mounted and provide for internal fan-out, splicing, and connection of the fiber optic cable to the patch panel assemblies.

2. Splice trays shall be provided for pigtail splicing. The WDC shall be provided with pass-thru splice trays for continuation of the fiber cable system to additional sites.

3. Provide one spare splice tray.

4. The WDC shall provide space and support the addition of future fiber cable splice trays.

5. The Wall Mount Fiber Distribution Center shall be Corning Cable Systems LANscape (WCH) series.

PART 3 EXECUTION

3.01 GENERAL

A. Provide all material, equipment, and labor to test and integrate the fiber optic system as indicated and as specified.

B. Installation shall comply with EIA/TIA Standards 568 and 569.

C. Fiber optic cables shall be continuous from component to component. Intermediate fiber splices shall not be allowed.

D. Provide delivery, storage, and handling of materials and equipment in accordance with Section 01600.

3.02 IDENTIFICATION

A. Label each termination point.

B. Label each cable, buffer tube, and fiber with permanent waterproof typewritten tags.

3.03 PHYSICAL CHECKOUT

A. General Procedures

1. Conduct physical checkout of the fiber optic data highway network.

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2. Physical checkout shall be performed prior to functional testing.

B. Check Procedures

1. Verify that fiber optic cable reels have been off-loaded from truck carefully and not damaged.

2. Submit to the Engineer all test data provided by the fiber manufacturer.

3. Verify that the optical fibers of the cable assembly are the type and quantity as specified and as recommended by the Instrumentation System Supplier.

4. Verify that cable construction is the type specified.

5. Verify that fiber optic patch panels have been installed plumb and level at locations indicated.

6. Verify that optical fiber connections or terminations within patch panels and splice closures are in accordance with cable manufacturer's recommendations.

3.04 FIBER OPTIC CABLE TESTING

A. General: The Contractor shall perform pre-installation and post-installation FOC tests. The Construction Manager shall be notified a minimum of 10 days in advance so that these tests are witnessed. All test equipment shall be traceable to NIST standards.

B. Test equipment: The Contractor shall use the following to perform pre-installation and post-installation FOC tests:

1. Optical time domain reflectometer (OTDR). The OTDR shall be laser precision, and be able to test single mode or multimode systems with a visual fault locator. The OTDR shall be as manufactured by Corning, Agilent Technologies, Fluke Networks, or equal.

C. Pre-installation Tests

1. The purpose of these tests is to perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications; is free of defects, breaks, and damages by transportation and manufacturing processes; and to provide baseline readings in dB.

2. Prior to removal of each cable from the delivery reel, all optical fibers within the cables shall be tested by the Contractor using an OTDR. The OTDR tests shall consist of end-to-end length and fiber attenuation (dB/km) measurements to ensure proper performance of the fiber optic cable. The tests shall be performed from both ends of each fiber to ensure complete fiber continuity within the cable structure.

3. Pre-installation, "on-reel" test results shall be compared with the manufacturer's test report delivered with the cable. Gross dissimilarities shall be noted and remedied between the Contractor and manufacturer. In all cases, all fibers must meet the optical attenuation specifications prior to cable installation.

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4. The Contractor shall perform tests on all reels of cable. The Construction Manager shall be notified a minimum of 15 days prior to any test.

5. The Contractor shall document each test and submit the report to the Construction Manager for review. Documentation shall consist of both hard copy and 3.5 inch electronic disk complete with all application software.

6. Cable shall not be installed until the Construction Manager has reviewed the test report.

D. Post-installation tests: After FOC has been installed and connectorized, the following tests shall be performed:

1. Visually inspect terminal connectors for out-of-round condition and surface defects such as micro-chips and cracks using a 200X (minimum) inspection microscope.

2. A recording OTDR shall be used to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall have an X-Y plotter to provide a hard copy record of each trace of each fiber. The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of 30 feet or more to display the required cable section.

3. The OTDR shall be calibrated for the correct index of refraction to provide proper length measurement for the known length of reference fiber.

4. A transmission test shall be performed with the use of a 1310 and 1550 nm stabilized light sources and 1310 nm/1550 nm power meters for SMF. This test shall be conducted in both directions on each fiber of each cable.

5. Hard and electronic copies of test documentation shall be submitted to the Construction Manager. The documentation shall include:
   a. The trace plot.
   b. Index.
   c. dB/km loss.
   d. Cable length.
   e. Date and time of test.
   f. Wavelength.
   g. Pulse width.
   h. The test site.
   i. Cable ID.
   j. Fiber number and type.
   k. Operator's initials.
   l. The Contractor shall compare the pre-installation test results to the post-installation results. If a deviation of greater than one dB occurs, the Construction Manager shall be notified in writing by the Contractor, and the cable shall be removed and replaced at no additional cost to the OWNER.

6. Upon completion of the previous tests, all FOC coils shall be secured with ends capped to prevent intrusion of dirt and water.

E. Certification of completion of pre- and post-fiber installation testing including test results shall be provided to the Engineer. Test results shall be submitted on paper in a binder, including

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results indicated in tables or a spreadsheet. Test results that exceed specification limits shall be noted. The electronic copy shall be included in the binder.

F. Required OTDR Trace Information

1. All traces shall display the entire length of cable under test, highlighting any localized loss discontinuities (installation-induced losses and/or connector losses). The trace shall display fiber length (in kilofeet), fiber loss (dB), and average fiber attenuation (in dB/km), as measured between two markers placed as near to the opposite ends of the fiber under test as is possible while still allowing an accurate reading. Care shall be taken to ensure that the markers are placed in the linear region of the trace, away from the front-end response and far-end Fresnel reflection spike. Time averaging shall be used to improve the display signal to noise ratio. The pulse width of the OTDR shall be set to a sufficient width to provide adequate injected power to measure the entire length the fiber under test.

2. If connectors exist in the cable under test, then two traces shall be recorded. One trace shall record the fiber loss (dB) and average attenuation (dB/km) of the entire cable segment under test, including connectors. The second trace shall display a magnified view of the connector regions, revealing the connector losses (dB). All connector losses shall be measured using the five-point splice loss measurement technique.

3. The OTDR trace shall also include the following information:
   a. The date and time of the test.
   b. The cable ID number.
   c. The cable segment ID number.
   d. The fiber color or sub-cable number.
   e. Launch point connector number.
   f. The optical wavelength used for the test.
   g. The refractive index setting of the OTDR.
   h. The pulse width setting of the OTDR.
   i. The averaging interval of the test.

3.05 TRAINING

A. Refer to Section 13303.

3.06 WARRANTY

A. Refer to Section 13300.

B. The Contractor shall provide an unconditional warranty on all installed cable for a minimum period of 20 years, commencing at the time of final acceptance by the Owner.

C. This Section describes the material and installation requirement for the fiber optic cabling system and associated equipment.

END OF SECTION

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SECTION 13330
CONTROL PANELS AND PANEL MOUNTED EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Refer to Section 13300.

B. Furnish and install control panels and panel mounted equipment as specified herein and shown on the Drawings.

C. All new panels and panel components shall match existing equipment makes and models wherever possible, so that system additions can be most easily integrated with respect to operation and maintenance training, spare parts inventory, and service contracts. Even when exact matches are not possible, equipment furnished must be fully compatible with the existing system. Color, size, and material of new panels should conform to that of existing panels.

D. Furnish the following panels and consoles. Each panel shall be supplied with full sub-panels and side panels as required.

E. All WRF panels shall follow design, layout, wiring and labeling of exiting panels that are to remain. PLC-2 and PLC-3 are direct replacement panels and shall be replicas of the existing. Drawings will be provided.

WRF PANEL SCHEDULE

Panel Designation	Size	Enclosure Rating & Type
PLC-1A in new Headworks Building	Maximum 72”H x 72”W x 24”D	NEMA Type 12, 1 or 2-door, steel construction, free standing. Front Access Only
PLC-2 in Blower Building	72”Hx30”Wx18”D	NEMA Type 12, 1-door, steel construction, free standing. Front Access Only
PLC-3 in RAS Pump Station	72”Hx30”Wx18”D	NEMA Type 12, 1-door, steel construction, free standing. Front Access Only
PLC-10 in new Electrical Building	Maximum 72”H x 72”W x 24”D	NEMA Type 12, 1 or 2-door, steel construction, free standing. Front Access Only

1.02 RELATED WORK

A. Refer to Section 13300.

1.03 SUBMITTALS

A. Refer to Section 13300.

B. Descriptive literature, bulletins, catalog cuts and Drawings for the equipment specified herein.

C. Complete bill of materials for the equipment.

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D. Spare parts list.

E. Panel Layout Drawings and Wiring Diagrams Submittal

1. Where direct hardwired interfaces exist between the PCSS control panels and vendor provided control panels furnished under other Divisions, the Contractor shall provide to the PCSS the approved submittals in order for the PCSS to provide complete wiring diagrams showing all wiring connections in the I/O system. This includes but is not limited to terminal block numbering, relay contact information, instruments, equipment, and control panel names. These drawings shall be included in the Final O&M submittal. Leaving this information blank on the Final Documentation drawings is not acceptable.

2. 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" in size. At 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. 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. For every control panel, 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 Contractor.

3. 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 PCSS. Wiring labeling used on the drawings shall match that shown on the Contract Documents or as developed by the PCSS and 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

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clearly identified and power sources noted. Submit final wire numbering scheme. Panel drawings shall be 11" x17" in size.

4. ISA Loop Wiring Diagrams: Not required

1.04 COORDINATION MEETINGS

A. Refer to Section 13300.

1.05 REFERENCE STANDARDS

A. Refer to Section 13300.

1.06 QUALITY ASSURANCE

A. Refer to Section 13300.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 13300.

1.08 NOMENCLATURE AND IDENTIFICATION

A. Refer to Section 13300.

1.09 MAINTENANCE

A. Refer to Section 13300.

B. Test Equipment:

1. Refer to Section 13300.

1.10 WARRANTY

A. Refer to Section 13300.

PART 2 PRODUCTS

2.01 GENERAL

A. Refer to Section 13300.

2.02 LIGHTNING/SURGE PROTECTION

A. Refer to Section 13300.

2.03 CONTROL PANEL GENERAL REQUIREMENTS

A. The dimensions within this Section and on the Contract Drawings are for general reference only. Ensure that final enclosure sizing and panel arrangements accommodate all required

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equipment for a fully integrated and operational system as specified herein and in the Contract Documents.

B. Each control panel and terminal cabinet shall bear the UL label. The UL label shall apply to the enclosure, the specific equipment supplied with the enclosure, and the installation and wiring of the equipment within and on the enclosure. If required for UL labeling, provide ground fault protective devices, isolation transformers, fuses and any other equipment necessary to achieve compliance with UL 508 requirement. The Drawings do not detail all UL 508 requirements.

C. All panel doors shall have a lock installed in the door handle, or a hasp and staple for padlocking. Locks for all panels provided under this Contract shall be keyed alike.

D. The devices designated for rear-of-panel mounting shall be arranged within the panel according to respective panel drawings and in a manner to allow for ease of maintenance and adjustment. Heat generating devices such as power supplies shall be located at or near the top of the panel.

E. The panels shall be completely fabricated, instruments and devices installed and wired at the PCSS's facility.

F. All components shall be mounted in a manner that shall permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component mounting shall be oriented in accordance with manufacturer's recommendations. The internal components shall be identified with suitable plastic or metal engraved nametags mounted adjacent to (not on) each component identifying the component in accordance with the drawing, specifications, and PCSS's data.

G. All exterior panel mounted equipment shall be installed with suitable gaskets, faceplates, etc. required to maintain the NEMA rating of the panel.

H. Nameplates

1. All panels and panel devices shall be supplied with suitable nameplates, which identify the panel and individual devices as required. Unless otherwise indicated, each device nameplate shall include up to three lines with the first line containing the device tag number as shown on the drawings, the second line containing a functional description (e.g., Recirculation Pump No. 1), and the third line containing a functional control description (e.g., Start).

2. Unless escutcheon plates are specified or unless otherwise noted on the Drawings, nameplates shall be 3/32-inch thick, black and white, Lamicoid with engraved inscriptions. The letters shall be Black against a White background unless otherwise noted. Edges of the nameplates shall be beveled and smooth. Nameplates with chipped or rough edges will not be acceptable.

3. Nameplate fasteners and mounting shall be epoxy adhesive or stainless steel screws for cabinet mounted nameplates

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4. For every panel, provide a panel nameplate with a minimum of 1" high letters. Provide legend plates or 1-in by 3-in engraved nameplates with 1/4-in lettering for identification of door mounted control devices, pilot lights, and meters.

5. Single lamicoid nameplates with multiple legends shall be used for grouping of devices such as selector switches and pilot lights that relate to one function.

I. Mounting Elevations

1. ISA Recommended Practice RP60.3 shall be used as a guide in layout and arrangement of panels and panel mounted components. Dimensions shall account for all housekeeping pads that panels will sit on once they are installed.

2. Centerline of indicators and controllers shall be located no lower than 48-inches or higher than 66-inches above the floor on a panel face.

3. Centerline of lights, selector switches, and pushbuttons shall be located no lower than 32-inches or higher than 70-inches above the floor on a panel face.

4. Tops of annunciators shall be located no higher than 86-inches above the floor on a panel face.

5. Installation of panel components shall conform to component manufacturers' guidelines.

2.04 PANEL MATERIALS AND CONSTRUCTION

A. Structure and Enclosure

1. Panels shall be of continuous welded-steel or FRP construction as shown on the Panel Schedule. Provide angle stiffeners as required on the back of the panel face to prevent panel deflection under instrument loading or operation. Internally the panels shall be supplied with a structural framework for instrument support purposes and panel bracing. The internal framework shall permit panel lifting without racking or distortion. Provide removable lifting rings designed to facilitate simple, safe rigging, and lifting of the control panels during installation.

2. Each panel shall be provided with full height, fully gasketed access doors where shown. Doors shall be provided with a three-point stainless steel latch (except for NEMA 4X panels) and heavy duty stainless steel locking handle. Rear access doors (if included) shall be conveniently arranged and sized such that they extend no further than 24-inches beyond the panel when opened to the 90-degree position. Front and side access doors shall be as shown. Panel access doors shall be provided with full length, continuous, piano type stainless steel hinges with stainless steel pins. Front access doors with mounted instruments or control devices shall be of sufficient width to permit door opening without interference from flush mounted instruments.

3. The panels, including component parts, shall be free from sharp edges and welding flaws. Wiring shall be free from kinks and sharp bends and shall be routed for easy access to other components for maintenance and inspection purposes.

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4. The panel shall be suitable for top and bottom conduit entry as required by the Electrical Drawings. For top mounted conduit entry, the panel top shall be provided with nominal one-foot square removable access plates, which may be drilled to accommodate conduit and cable penetrations. All conduit and cable penetrations shall be provided with ground bushings, hubs, gasketed locknuts, and other accessories as required to maintain the NEMA rating of the panel and electrical rating of the conduit system.

5. All panels in indoor, dry, non-corrosive environments shall be NEMA 12 unless otherwise noted. All panels in outdoor, wet, and non-chemically corrosive environments shall be NEMA 4 unless otherwise noted. Panels in chemically corrosive environments shall be NEMA 4X unless otherwise noted. All panels located in a hazardous location shall be rated for the type of hazard (e.g., NEMA 7 for Class 1, Division 1).

B. Freestanding and Floor-Mounted Vertical Panels

1. Freestanding and floor-mounted vertical panels shall meet the NEMA classification as shown on the drawings or specified herein. The panels shall be constructed of 12 gauge sheet steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated panels shall be constructed of 316 stainless steel, unless FRP is specifically indicated to be provided. Front panels or panels containing instruments shall be not less than 10 gauge stretcher leveled sheet steel, reinforced to prevent warping or distortion.

C. Wall and Unistrut Mounted Panels

1. All wall and Unistrut mounted panels shall meet the NEMA classification as shown on the drawings or specified herein. The panels shall be constructed of not less than USS 14 gauge steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated wall mounted panels shall be constructed of 316 stainless steel, unless FRP is specifically indicated. FRP panels shall be used in chlorine areas. All FRP panels located in direct sunlight shall be provided with a protective coating and sun shield to prevent discoloration and cracking.

D. Finish Requirements

1. All sections shall be descaled, degreased, filled, ground and finished. The enclosure when fabricated of steel shall be finished with two rust resistant phosphate prime coats and two coats of enamel, polyurethane, or lacquer finish which shall be applied by either the hot air spray or conventional cold spray methods. Brushed anodized aluminum, stainless steel, and FRP panels will not require a paint finish.

2. The panels shall have edges ground smooth and shall be sandblasted and then cleaned with a solvent. Surface voids shall be filled and ground smooth.

3. Immediately after cleaning, one coat of a rust-inhibiting primer shall be applied inside and outside, followed by an exterior intermediate and top coat of a two-component type epoxy enamel. A final sand-ing shall be applied to the intermediate exterior coat before top coating.

4. Apply a minimum of two coats of manufacturer’s standard, flat light-colored lacquer, on the panel interior after priming.

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5. Unless otherwise noted, the finish exterior colors shall be ANSI 61 gray with a textured finish.

E. Print storage pockets shall be provided on the inside of each panel. The storage pockets shall be steel, welded on to the door, and finished to match the interior panel color. The storage pocket shall be sufficient to hold all of the prints required to service the equipment, and to accommodate 8.5 inch by 11 inch documents without folding.

F. Where specified on the Panel Schedule, a folding shelf shall be provided on the inside of the door on all free-standing and floor-mounted panels. The shelf shall be suitable for a laptop computer and shall be placed such that an open laptop computer does not interfere with any door-mounted devices. The folded shelf shall not interfere with any internal panel components when the door is closed. The folding shelf shall automatically lock in the horizontal position when raised. The folding shelf shall be approximately 18 inches wide by 12 inches deep and shall have a minimum distributed load rating of 100 pounds. All parts shall be made of heavy gauge steel and shall be painted white or finished to match the interior panel color.

2.05 ENVIRONMENTAL CONTROL

A. All panels shall be provided with louvers, sun shields, heat sinks, forced air ventilation, or air conditioning units as required to prevent temperature buildup inside of panel. The internal temperature of all panels shall be regulated to a range of 45 Deg F to 104 Deg F under all conditions. Under no circumstances shall the panel cooling or heating equipment compromise the NEMA rating of the panel.

B. Except for panels mounted with their backs directly adjacent to a wall, louvers shall be in the rear of the panels, top and bottom, and shall be stamped sheet metal construction.

C. For panels mounted with their backs directly adjacent to a wall, louvers shall be on the sides.

D. Forced air ventilation fans, where used, shall provide a positive internal pressure within the panel, and shall be provided with washable or replaceable filters. Fan motors shall operate on 120-volt, 60-Hz power.

E. For panels with internal heat that cannot be adequately dissipated with natural convection and heat sinks, or forced air ventilation, an air conditioner shall be provided.

F. Provide custom fabricated sun shields for all outdoor panels in accordance with the following requirements:

1. Sun shields shall be fabricated from minimum 12 gauge Type 316 stainless steel. Units shall be designed, fabricated, installed, and supported to fully cover and shade the top, sides and back of the enclosure, and to partially shade the front panel of the enclosure, from direct exposure to sunlight from sunrise to sunset.

2. Depending on overall size, sun shields may be fabricated in single or multiple segments for attachment to the enclosure support framing or to separate free standing framing around the enclosure.

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3. Sun shields shall not be attached directly to the enclosure by drilling holes through, or welding studs to, the enclosure surfaces, and shall be designed and mounted to provide a minimum 3-inch air gap all around the enclosure for air circulation and heat dissipation.

4. The top section of all sun shields shall be sloped at a minimum angle of 5 degrees from horizontal. For wall mounted enclosures, the top section shall slope downward away from the wall and towards the front of the enclosure. For free standing, floor mounted and frame mounted enclosures the top section shall slope downward towards the back side of the enclosure.

5. The front edge of the top section of all sun shields shall incorporate a narrow and more steeply sloped drip shield segment which sheds water away from the front of the enclosure and prevents it from dripping or running directly onto the front panel of the enclosure.

6. All seam welds used in sun shield fabrication shall be continuous and shall be ground smooth.

7. All exposed corners, edges and projections shall be smooth rounded or chamfered to prevent injury.

G. All outdoor enclosures and enclosures located in unheated areas indoors or in areas subject to humidity and moisture shall be provided with an integral heater, fan, and adjustable thermostat to reduce condensation and maintain the minimum internal panel temperature. Mount the unit near the bottom of the enclosure with discharge away from heat-sensitive equipment. Heater shall be Hoffman DAH or approved equal and shall be of adequate wattage, as defined by thermal calculations.

2.06 CORROSION CONTROL

A. Panels shall be protected from internal corrosion by the use of corrosion-inhibiting vapor capsules as manufactured by Northern Technologies International Corporation, Model Zerust VC ; Hoffman Model AHCI; or equal.

2.07 CONTROL PANEL - INTERNAL CONSTRUCTION

A. Internal Electrical Wiring

1. All interconnecting wiring shall be stranded, type MTW, and shall have 600 volt insulation and be rated for not less than 90 degrees Celsius. Wiring for systems operating at voltages in excess of 120 VAC shall be segregated from other panel wiring either in a separate section of a multi-section panel or behind a removable Plexiglas or similar dielectric barrier. Panel layout shall be developed such that technicians shall have complete access to 120 VAC and lower voltage wiring systems without direct exposure to higher voltages.

2. Power distribution wiring on the line side of fuses or breakers shall be 12 AWG minimum. Control wiring on the secondary side of fuses shall be 16 AWG minimum. Electronic analog circuits shall utilize 18 AWG shielded, twisted pair, cable insulated for not less than 600 volts.

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3. Power and low voltage DC wiring systems shall be routed in separate wireways. Crossing of different system wires shall be at right angles. Different system wires routed parallel to each other shall be separated by at least 6-inches. Different wiring systems shall terminate on separate terminal blocks. Wiring troughs shall not be filled to more than 60 percent visible fill.

4. Terminations
   a. All wiring shall terminate onto single tier terminal blocks, where each terminal is uniquely and sequentially numbered. Direct wiring between field equipment and panel components is not acceptable.
   b. Multi-level terminal blocks or strips are not acceptable unless they are approved by the Engineer. If approved, they shall be mounted on angled din rail elevated from the back panel.
   c. Terminal blocks shall be arranged in vertical rows and separated into groups (power, AC control, DC signal). Each group of terminal blocks shall have a minimum of 25 percent spares.
   d. Terminal blocks shall be the compression type, fused, unfused, or switched as shown on the Contract Drawings or specified elsewhere in Division 13.
   e. Discrete inputs and outputs (DI and DO) shall have two terminals per point with adjacent terminal assignments. All active and spare PLC and controller points shall be wired to terminal blocks.
   f. Analog inputs and outputs (AI and AO) shall have three terminals per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the PLC cabinet. All active and spare PLC and controller points shall be wired to terminal blocks.
   g. Wire and tube markers shall be the sleeve type with heat impressed letters and numbers.
   h. Only one side of a terminal block row shall be used for internal wiring. The field wiring side of the terminal shall not be within 6-inches of the side panel or adjacent terminal or within 8-inches of the bottom of free standing panels, or within 3-inches of stanchion mounted panels, or 3-inches of adjacent wireway.
   i. Circuit power from the SCADA cabinet out to field devices (switches, dry contacts etc.) that are used as discrete inputs to the PLC input cards shall be isolated with an isolating switch terminal block with flip cover that is supplied with a dummy fuse. Isolation switch block shall be an Allen Bradley Model 1492-H7 or equal. One isolating switch terminal block per loop numbered piece of equipment and one per spare I/O point is acceptable.
   j. All PLC discrete outputs to the field shall be isolated with an isolating fuse switch terminal block with a flip cover and a neon blown fuse indicator. The single circuit fusible terminal block shall be an Allen Bradley 1492-H4 or equal.

5. All wiring to hand switches and other devices, which are live circuits independent of the panel's normal circuit breaker protection, shall be clearly identified as such.

6. All wiring shall be clearly tagged and color coded. All tag numbers and color coding shall correspond to the panel wiring diagrams and loop drawings prepared by the PCSS. All power wiring, control wiring, grounding, and DC wiring shall utilize different color insulation for each wiring system used. The color coding scheme shall be:
   a. Incoming 120 VAC Hot - Black

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b. 120 VAC Hot wiring downstream of panel circuit breaker – Red
c. 120 VAC Hot wiring derived from a UPS system – Red with Black stripe
d. Three phase power – Brown, Orange, Yellow, and Green ground or as specified in Division 16.
e. 120 VAC neutral - White
f. Ground - Green
g. DC power or control wiring – Blue
h. DC analog signal wiring – Black (+), White (-)
i. Foreign voltage – Yellow

7. Provide surge protectors on all incoming power supply lines at each panel per the requirements of Section 13300.

8. Wiring trough for supporting internal wiring shall be plastic type with snap-on covers. The side walls shall be open top type to permit wire changing without disconnecting. Trough shall be supported to the subpanel by stainless steel screws. Trough shall not be bonded to the panel with glue or adhesives.

9. Each panel shall have a LED light fixture, mounted internally to the ceiling of the panel. Light fixture shall be switched and shall be complete with the lamp.

10. Each panel shall have a specification grade duplex convenience receptacle with ground fault interrupter, mounted internally within a stamped steel device box with appropriate cover. Convenience receptacle shall not be powered from a UPS and shall be protected by a dedicated fuse or circuit breaker.

11. Each panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturer's recommendations.

12. Each panel shall be provided with a separate copper power grounding bus (safety) in accordance with the requirements of the National Electrical Code.

13. Each panel shall have control, signal, and communication line surge suppression in accordance with Section 13300.

14. All microprocessor-based electronic devices in the panel that are powered by 120VAC shall be powered by the UPS (refer to appropriate Section in Division 13).

15. Each panel shall be provided with a circuit breaker to interrupt incoming power.

16. Additional electrical components including transformers, motor starters, switches, circuit breakers, etc. shall be in compliance with the requirements of Division 16.

2.08 ELECTRICAL COMPONENTS

A. All operating control devices and instruments shall be securely mounted on the exterior door. All controls shall be clearly labeled to indicate function and shall be in accordance with the electrical area classification indicated on the Electrical Contract Drawings.

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B. The control panel shall be provided with a lightning and surge protection unit on the line side of the main circuit breaker. Unit shall be 600 Volt, 3 Phase, General Electric "Tranquell" Series, or equal.

C. Specific control devices, control descriptions and other data are specified under the detailed specification for the mechanical equipment with which the control panel is supplied.

2.09 PILOT TYPE INDICATING LIGHTS

A. Type: Energy efficient Solid State LED Lamps.

B. Functional:

1. Units shall be provided with low voltage LED lamps suitable for the voltage supplied.

2. Lights supplied with 120V AC power shall have integral reduced voltage transformers.

3. Lamps shall be replaceable from the front of the unit.

C. Physical:

1. Lens color:
   a. Running, on, open – Green.
   b. Stopped, off, closed – Red.
   c. Alarm – Amber.
   d. White - Power on
   e. Blue - All other status indications not covered by the above
   f. Lens caps shall be approximately .46 inch diameter. Provide legend faceplates engraved to indicate the required function of each device; NEMA rating - 4X.

D. Manufacturer(s):

1. Cutler-Hammer.

2. Allen Bradley.

3. General Electric.

4. Square D.

5. Crouse Hinds (NEMA 7).

6. Equal.

2.10 SELECTOR SWITCHES AND PUSHBUTTONS

A. Type:

1. Control devices shall be heavy-duty oil tight type with stackable contact blocks.

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B. Functional:

1. Provide contact arrangement and switching action as required for the control system specified.

C. Physical:

1. For 120 VAC service provide contacts rated 10 amps at 120 VAC, for 24 VDC service provide silver sliding contacts rated 5 amps at 125 VDC, for electronic (millivolt/ milliamp) switching provide contacts rated lamp at 28 VDC.

2. Pushbuttons shall have flush type operators.

3. Selector switches shall have knob or wing lever operators; NEMA rating - 4X; Provide legend plates denoting switch/pushbutton position/ function.

D. Manufacturer(s):

1. Cutler-Hammer.

2. Allen Bradley.

3. General Electric.

4. Square D.

5. Crouse Hinds (NEMA 7).

6. Equal.

2.11 POTENTIOMETER

A. Type:

1. Device shall be heavy-duty 30 mm oil tight type.

B. Functional:

1. 270 degree dial

2. Rated for 1,000 ohms.

C. Physical:

1. Mounting: Suitable for panel mounting

2. NEMA 4X rating; escutcheon plates scaled in engineering units.

D. Manufacturer(s):

1. Allen Bradley Co.

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2. Cutler-Hammer.

3. Square D.

4. Equal.

2.12 GENERAL PURPOSE RELAYS AND TIME DELAYS

A. Type:

1. General purpose plug-in type.

B. Functional:

1. Contact arrangement/function shall be as required to meet the specified control function; Mechanical life expectancy shall be in excess of 10 million.

2. Duty cycle shall be rated for continuous operation; Units shall be provided with integral indicating light to indicate if relay is energized.

3. Solid state time delays shall be provided with polarity protection (DC units) and transient protection.

4. Time delay units shall be adjustable and available in ranges from .1 second to 4.5 hours.

C. Physical:

1. For 120 VAC service provide contacts rated 10 amps at 120 VAC, for 24 VDC service provide contacts rated 5 amps at 28 VDC, for electronic (milliamp/millivolt) switching applicator provide gold plated contacts rated for electronic service; relays shall be provided with dust and moisture resistant covers.

D. Options/Accessories Required:

1. Provide mounting sockets with pressure type terminal blocks rated 300 volt and 10 amps.

2. Provide mounting rails/holders as required.

E. Manufacturer(s):

1. Potter and Brumfield

2. Equal.

2.13 SIGNAL RELAY SWITCHES (CURRENT TRIPS)

A. Type:

1. Solid state, ASIC technology, electronic type.

B. Functional:

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1. Input: 4-20 mA.

2. Output: Isolated contact output, double pole double throw, rated 5 amps at 120 VAC.

3. Accuracy: 0.1 percent.

4. Protection: Provide RFI protection.

5. Deadband: Adjustable between 0.1 and 5.0 percent of span.

6. Set point Adjustment: Single Point alarms shall be adjustable to trip on rising or falling input signal, dual point alarms shall be adjustable to trip on rising and falling input signals.

7. Repeatability: Trip point repeatability shall be at least 0.1 percent of span.

C. Physical:

1. Mounting: DIN rail.

D. Manufacturer(s):

1. Action Instruments Slim Pak.

2. Acromag.

3. Equal.

2.14 SIGNAL ISOLATORS/BOOSTERS/CONVERTERS

A. Type:

1. Solid state, ASIC technology; electronic type.

B. Functional:

1. Accuracy: 0.15 percent.

2. Inputs: Current, voltage, frequency, temperature, or resistance as required.

3. Outputs: Current or voltage as required.

4. Isolation: There shall be complete isolation between input circuitry, output circuitry, and the power supply.

5. Adjustments: Zero and span adjustment shall be provided.

6. Protection: Provide RFI protection.

C. Physical:

1. Mounting: DIN Rail.

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D. Manufacturer(s):

1. Action Instruments Slim Pak.

2. Acromag.

3. Equal.

2.15 SIGNAL SELECTORS, COMPUTATION, AND CONDITIONING RELAYS

A. Type:

1. Solid state, ASIC technology, electronic type.

B. Functional:

1. Inputs: 4-20 mA.

2. Outputs: 4-20 mA.

3. Protection: Provide RFI protection.

4. Operation: The relay shall multiply, add, subtract, select, extract the square root, or perform the specified conditioning/ computation function required. All inputs shall be able to be individually rescaled and biased as required.

5. Isolation: All inputs, outputs, and power supplies shall be completely isolated.

6. Accuracy: 0.35 percent of span.

7. Adjustments: Multi turn potentiometer for zero, span, scaling, and biasing.

C. Physical:

1. Mounting: DIN rail.

D. Manufacturer(s):

1. Action Instruments Slim Pak.

2. Acromag.

3. Equal.

2.16 INTRINSIC SAFETY BARRIERS

A. Type:

1. Barriers shall be of the solid state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe usage in hazardous areas.

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2. Provide a barrier for instrumentation and equipment transmitting analog or digital signals that originate in a hazardous area as indicated in the design documents.

B. Options Required:

1. Barriers shall match power supply provided.

2. Barriers shall be located in non-hazardous areas.

C. Manufacturer(s):

1. Siemens Water Technologies – IS1 (4-20mA) and IS6 (dry contacts)

2. Gems – 54800 (4-20mA) and 65800 (dry contacts)

3. R. Stahl - Intrinspak

4. Equal.

2.17 EMERGENCY ALARM BEACON AND AUDIBLE HORN

A. Beacon alarm light:

1. Type:
   a. Beacon alarm light.

2. Physical:
   a. Beacon alarm light for building exterior mounting shall be 120 VAC, flush mounted, weatherproof construction.
   b. A 750,000-candle power xenon strobe tube and red polycarbonate lens.

3. Manufacturer(s):
   a. Federal Signal.
   b. Edwards.
   c. Wheelock.
   d. Equal.

B. Alarm Horn:

1. Type:
   a. Alarm horn shall be vibrating type for 120 Volts, 60 Hz.

2. Manufacturer(s):
   a. Federal Signal Corp.
   b. Edwards Co.
   c. Benjamin.
   d. Equal.

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2.18 INTRINSIC SAFETY BARRIERS (FOR 2-WIRE TRANSMITTER SYSTEMS)

A. Intrinsic safety barriers shall be passive devices requiring no external voltage supply and supplied with series resistors, series fuse and shunt zener diodes to limit the transfer of energy to levels required by intrinsically safe protection between safe and hazardous locations.

B. Unit shall be Factory Mutual approved and certified for use in accordance with National Fire Protection Association (NFPA 493).

C. Manufacturer(s):

1. P&F.

2. Gems.

3. Unitech.

4. Equal.

2.19 24 VDC POWER SUPPLIES

A. Provide a 24 VDC power supply in the control panel to power field instruments, panel devices, etc., as required. Equip the power supply with a power on/off circuit breaker.

B. The 24 VDC power supply shall meet the following requirements:

1. Input power: 115 VAC, plus or minus 10 percent, 60 Hz.

2. Output voltage: 24 VDC.

3. Output voltage adjustment: 5 percent.

4. Line regulation: 0.05 percent for 10 volt line change.

5. Load regulation: 0.15 percent no load to full load.

6. Ripple: 3 mV RMS.

7. Operating temperature: 32 to 140 degrees Fahrenheit.

C. Size the 24 VDC power supply to accommodate the design load plus a minimum 25 percent spare capacity.

D. If power supply on/off status signal is shown, provide a relay contact (internal to the power supply or external if the power supply is not so equipped) to indicate on/off status of the power supply.

E. Provide output overvoltage and overcurrent protective devices with the power supply to protect instruments from damage due to power supply failure and to protect the power supply from damage due to external failure.

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F. Mount the 24 VDC power supply such that dissipated heat does not adversely affect other panel components.

G. Manufacturer(s):

1. Phoenix Contact

2. Weidmuller

3. Or Equal

2.20 DIGITAL PANEL METER

A. Type:

1. Electronic, 3.5 digit, 0.56 inch high efficiency LED display.

B. Operation:

1. To accept 4-20 mA DC input signal and provide indication in Engineering Units of measured variable.

C. Functional:

1. Power supply: 115 VAC, plus or minus 10 percent, 50/60 Hz, 10 VA.

2. Input: 4-20 mA DC into 100 ohms.

3. Indication: 0.56 inch LED display.

D. Physical:

1. Case size nominal 2.5 inch high by 5 inch wide by 6 inch deep.

2. Case type: watertight and dust-tight (NEMA 4X).

3. Mounting: flush panel suitable for high density mounting arrangements.

E. Performance: Linear input accuracy plus or minus 0.05 percent of calibrated span, plus or minus 1 count.

F. Manufacturer(s):

1. Precision Digital.

2. Red Lion.

3. Equal.

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2.21 SINGLE PHASE UPS - INTERNAL TO CONTROL PANELS

A. SYSTEM DESCRIPTION

1. Provide an industrially rated continuous-duty, on-line, solid state, line interactive, single-phase uninterruptible power system.

2. The UPS shall provide power conditioning and power backup for PLC, communications hardware, and other critical electronic loads as indicated on the Drawings.

3. The UPS system shall consist of the following major components:
   a. Rectifier and battery charger.
   b. Inverter.
   c. Batteries.
   d. Other features as described in this specification and as indicated on the Drawings.

4. The UPS shall be
   a. Allen Bradley 1609-U UPS
   b. Sola Hevi Duty SDU UPS
   c. Or equal

B. GENERAL REQUIREMENTS

1. Battery protection shall be provided an internal circuit breaker disconnect.

2. Current limiting circuitry shall protect the inverter output under any load condition.

3. The AC output neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall have an equipment ground terminal. Provisions for installation of a bonding connector shall be provided.

4. The UPS shall be suitable for installation in a UL508A listed panel.

5. The UPS shall be DIN rail mountable.

6. UL recognized components for industrial applications in accordance with UL508 without derating.

C. PERFORMANCE REQUIREMENTS

1. Ratings
   a. Output power: 350VA – 800VA
   b. Battery runtime: 14 minutes at full-load, 34 minutes at half-load

2. Environment:
   a. Ambient temperature: 0 to 40 degrees C.
   b. Elevation: Up to 500-ft above mean sea level
   c. Relative humidity: 1 to 95 percent non-condensing

3. System Input – Primary source:

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a. Single input: Nominal Input Voltage: 120 VAC
b. Frequency: 45 to 65 Hz.
c. Input Power Factor: 0.95 lag minimum, 50 to 100 percent load.
d. Input Surge Withstandability: Per IEEE 587/ANSI C62.41. Category A and B, (6 kV).

4. System Output:
   a. Nominal Output Voltage:120 VAC
   b. Frequency: 60 Hertz plus or minus 3 Hertz.
   c. 100 percent load with 3:1 Crest Ratio
   d. Frequency Slew Rate: 1 Hz/second. (Adjustable at startup)

5. AC to AC Efficiency: (100 percent load @ rated PF): 88 percent online, 86 percent on battery.

6. Acoustical Noise: Noise generated by the UPS under normal operation shall not exceed 65 dBA (60 dBA typical) at one meter from any surface, measured at 25 degrees C (77 degrees F) and full load.

7. EMI Suppression: The UPS shall meet FCC Rules and Regulation 47, Part 15, Subpart J, for Class A devices.

D. MODES OF OPERATION

1. The UPS shall operate as a line interactive on-line, fully automatic system in the following modes:
   a. Normal: The critical load shall be continuously supplied with filtered and regulated AC power by the inverter. The rectifier/battery chargers shall derive power from the preferred AC source and supply DC power to the inverter while simultaneously floats charging the batteries.
   b. Emergency: Upon failure of the preferred ac power source, the critical load shall continue to be supplied by the inverter. Inverter power shall be supplied without switching from the storage battery. There shall be no interruption to the critical load upon failure or restoration of the preferred ac sources. If the AC source cannot be restored before the battery discharges to its low voltage dropout value, the UPS shall automatically shut itself down in an orderly manner.
   c. Recharge: Upon restoration of the AC source, the rectifier/battery charger shall power the inverter and simultaneously recharges the batteries. This shall be an automatic function causing no interruption to the critical load.

E. RECTIFIER/CHARGER

1. The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to the inverter and for battery charging. The rectifier/charger shall be a solid-state SCR/IGBT power transistor type with constant voltage/current limiting control circuitry.

F. INVERTER

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1. The inverter shall include all solid-state equipment and controls to convert DC power from the rectifier/charger or battery to a regulated AC power for powering the critical load. The inverter shall use Insulated Gate Bipolar Transistors (IGBTs) in a phase-controlled, pulse width modulated (PWM) design capable of providing the specified AC output.

2. The inverter shall be capable of supplying current and voltage for overloads exceeding 100 percent. The inverter is to provide 150 percent of full load for 30 seconds and 125 percent of full load for 2 minutes. A status indicator and audible alarm shall indicate overload operation.

3. The output voltage shall be maintained to within plus or minus 5 percent.

4. The output voltage total harmonic distortion (THD) shall not be greater than 5 percent at full load.

G. BATTERIES

1. The batteries shall be High Temperature sealed, maintenance-free, high-rate discharge, lead-acid cells suitable for use indoors with no off gassing, or water addition requirements. Batteries shall not require special ventilation. The battery shall consist of one or more battery banks with the number of cells required to meet the requirements of the rest of these specifications.

2. Battery Design Life: two-four years.

H. CONTROLS AND MONITORING

1. Microprocessor-controlled circuitry: Fully automatic operation of the UPS shall be provided through the use of a microprocessor-based controller. All operating and protection parameters shall be firmware-controlled. The logic shall include system test capability to facilitate maintenance and troubleshooting. Startup, battery charging, and transfers shall be automatic functions.

2. Front Indicators: As a minimum, the following indicators shall be provided on the UPS control panel:
   a. On-line (UPS is using utility power to power the load)
   b. In bypass mode
   c. On battery
   d. Overload
   e. Replace battery / battery disconnected
   f. Fault
   g. Bar graph for utility voltage
   h. Bar graph for battery

3. Front Panel Controls: As a minimum, the following controls shall be provided on the UPS control panel
   a. Power On/Off
   b. Self test
   c. Alarm silence
   d. Cold start

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e. Load off

4. Remote alarm and status indication: Isolated SPDT dry contacts shall be provided to indicate UPS status for remote monitoring. Contacts shall be rated for 250VAC @ 5A or 30VDC @ 5A Individual contacts shall be provided for separate annunciation of the following alarm and status conditions:
   a. On UPS Power
   b. Low Battery
   c. UPS Fail

2.22 SPARE PARTS

A. General requirements for spare parts are specified in Section 13300.

B. The following control panel spare parts shall be furnished at each site location; Wastewater Reclamation Facility and Collection/Distribution System:

1. Timers and sockets - Two of each type installed, at each location above.

2. Relays and sockets - Two of each type installed, at each location above.

3. 24VDC power supplies – One of each type installed, at each location above.

4. Fuses and circuit breakers - 10% (minimum of 10 fuses and 2 circuit breakers) of each type and size installed, at each location above.

5. Light bulbs - 10% (minimum of 10) of each type installed. For LED type lights, 5% (minimum of 3) of each color installed, at each location above.

6. Selector switches/pushbuttons - Two of each type installed including contact blocks, at each location above.

7. Provide touch-up paint, of each type and color used for all cabinets, panels, and consoles supplied, at each location above.

PART 3 EXECUTION

3.01 INSTALLATION

A. The panels shall be installed at locations as shown on the Contract Drawings.

B. Refer to Section 13300.

3.02 TESTS

A. Refer to Section 13300.

END OF SECTION

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SECTION 13340
INSTRUMENTATION AND CONTROLS – INSTRUMENTS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This section covers the furnishing, installation, and services for instruments.

B. Refer to Section 13300.

1.02 RELATED WORK

A. Refer to Section 13300.

1.03 SUBMITTALS

A. Submit complete documentation of all field instruments using ISA-TR20.00.01-2001 (updated in 2004-2006) data sheet formats. Submit a complete Bill of Materials (BOM) or Index that lists all instrumentation equipment. The list shall be sorted by Loop Number.

B. Submit separate data sheets for each instrument including:

1. Plant Equipment Number and ISA tag number per the drawings
2. Product (item) name used herein and on the Drawings
3. Manufacturer's complete model number
4. Location of the device
5. Input - output characteristics
6. Range, size, and graduations in engineering units.
7. Physical size with dimensions, enclosure NEMA classification and mounting details in sufficient detail to determine compliance with requirements.
8. Materials of construction for enclosure and wetted parts.
9. Instrument or control device sizing calculations where applicable
10. Certified calibration data for all flow metering devices.
11. Two-wire or four-wire device type as applicable.

C. Submit catalog cuts for all instruments. Submit descriptive literature for each hardware component, which fully describes the units being provided.

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D. Submit index and data sheets in electronic format as well as hard copies on 8-1/2" x 11" formats. Electronic format shall be in Microsoft Excel or Word. Submit electronic copy on CD-ROM or DVD disk.

1.04 INSTRUMENT TAGS

A. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as indicated in the Drawings, shall be provided on each piece of equipment supplied under this Section and related sections. Equipment shall be tagged before shipping to the site.

B. Provide 1/8-in by 3/8-in, Type 316 stainless steel button head machine screws.

C. All supplied instrument transmitters and instrument transmitter elements shall have a stainless steel identification tag attached to each transmitter and element prior to shipment. Tag shall be attached via stainless steel chain or stainless steel wire (24 gauge min) to a non-removable part of the device. The tag size shall be a minimum of 1.5 square inches. Tag shall include the ISA alphanumeric instrument number as indicated in the P&ID, loop, and detail drawings. The alphanumeric instrument number shall be stamped into the tag and shall have a minimum of 3/16-in high alphanumeric characters.

1.05 APPROVALS/CERTIFICATIONS

A. Instruments for hazardous locations shall have Factory Mutual (FM), Canadian Standards Association (CSA), and CENELEC approvals and certifications as specified herein and as indicated on the Drawings or in the Instrument Device Schedule. The instrument specifications in Part 2 state the Class, Division, and gas groups for FM/CSA approval, followed in parenthesis by the CENELEC certification; however, instruments provided are only required to have the approval/certification stated above. The instrument shall have a stainless steel tag identifying the relevant approval or certification.

PART 2 PRODUCTS

2.01 MAGNETIC FLOWMETER

A. Flow Element

1. Type:
   a. Pulsed DC type.

2. Function/Performance:
   a. Operating Temperature: Process liquid temperatures of 0 to 140 degrees F, ambient of -30 to 150 degrees F.
   b. Pressure rating: Equal to piping system where meter is installed.
   c. Additional: Meter shall be capable of running empty indefinitely without damage to any component.
   d. Additional: Meter shall be capable of bidirectional operation where required.

3. Physical:
   a. Metering Tube: 304 stainless steel or equivalent.

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b. Flanges: ANSI 150 lb. or DIN PN 16 carbon steel, as required by the piping system, unless otherwise indicated. ANSI 150 lb. or DIN PN 16 stainless steel flanges shall be used on all SS process pipes.
c. Liner: Polyurethane or composite elastomer, or as required for compatibility with process fluid as indicated on the Drawings or herein.
d. Electrodes: 316 stainless steel, or as required for compatibility with process fluid as indicated on the Drawings or herein.
e. Housing: For meters with remote mounted transmitters, meters below grade shall be suitable for submergence for up to 48 hours to a depth of 30 ft (9m). Meters above grade shall be NEMA 4X (IP65). Where hazardous areas are indicated on the Drawings, the equipment shall be rated for that area.
f. Finish: All external surfaces shall have a chemical and corrosion resistant finish.

4. Accessories/Documentation Required:
   a. Factory calibration: All meters shall be factory calibrated. A copy of the calibration report shall be included in the O&M manual.
   b. Grounding: Meter shall be grounded in accordance with the manufacturer's recommendation. Provide ground ring, ground wires, gaskets, etc., as required. All materials shall be suitable for the liquid being measured and must be compatible with process fluid and with the process pipe.
   c. Provide cable for installation between the flowtube and the transmitter. Length shall be as required by installation as indicated on the Drawings.

B. Flow Converter/Transmitter

1. Type:
   a. Microprocessor based, intelligent transmitter compatible with flowtube provided.
   b. Wall or surface mounting remote from the flowtube, as shown on the drawings or as required by the physical location.

2. Functional/Performance:
   a. Accuracy (including flowtube): 0.5% of rate or better.
   b. Operating Temperature: –20 to 140 degrees F.
   c. Power Requirements: 120 VAC
   d. Output: Isolated 4-20 mA with HART protocol. Current output adjustable over the full range of the instrument. Provide a second 4-20mA output to indicate reverse flow where bidirectional flow is required.
   e. Diagnostics: Self diagnostics with on screen display of faults.
   f. Display: Digital indicator displaying flow in engineering units.
   g. Totalizer: A fully configurable totalizer integral to the transmitter. Totalized flow shall be displayed.
   h. Empty Tube Zero: The transmitter shall include a feature that will lock the output at zero when no flow is detected. The empty tube zero feature shall be enabled automatically when the transmitter detects no flow or manually through a contact input.

3. Physical:
   a. Transmitter shall be suitable for surface or pipe stand mounting.
   b. Enclosure shall be NEMA 4X (IP65).

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4. Accessories/ Required:
   a. Keypad where required for transmitter configuration.

C. Manufacturer:

1. ABB Instruments WaterMaster

2. Endress+Hauser Promag

3. Krohne Optiflux 2000 or 4000 Series

4. Rosemount Series 8750 series

5. Siemens Sitrans FM MAG

D. Units to be Furnished by PCSS:

1. FE/FIT 100-1: Influent Flow
   a. Service: Wastewater (influent)
   b. Pipe Size: 30 inch
   c. Range: 0-30 mgd

2. FE/FIT 100-2: Influent Flow
   a. Service: Wastewater (influent)
   b. Pipe Size: 30 inch
   c. Range: 0-30 mgd

3. FE/FIT 410: Equalization Gravity Flow
   a. Service: Wastewater (influent)
   b. Pipe Size: 14 inch
   c. Range: 0-10 mgd

4. FE/FIT 415: Equalization Pump Station Flow
   a. Service: Wastewater (influent)
   b. Pipe Size: 36 inch
   c. Range: 0-30 mgd

5. FE/FIT 440: Equalization Return Flow
   a. Service: Wastewater (influent)
   b. Pipe Size: 24 inch
   c. Range: 0-20 mgd

6. FE/FIT 710: Plant Effluent Flow
   a. Service: Wastewater (effluent)
   b. Pipe Size: 42 inch
   c. Bidirectional
      1) Range of forward flow (Effluent): 0-33 mgd
      2) Range of reverse flow (Reclaimed PS): 0-12 mgd

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2.02 NON-CONTACT AREA VELOCITY FLOW TRANSMITTER

A. General

1. The flow meter shall consist of three components; an electronics transmitter unit, sensor, and interconnecting cable. The sensor shall combine advanced radar velocity sensing technology with ultrasonic pulse echo level sensing to remotely measure open channel flow.

B. Sensors

1. Type: The sensor shall consist of three transducers housed in a single polystyrene watertight enclosure. The sensor shall be of the non-contact type and be mounted above the flow surface. The three transducers shall be a digital Doppler radar for surface velocity, an ultrasonic pulse echo for fluid level, and a piezoresistive pressure measurement for surcharge level. The radar beam shall transmit signals, which interact with the fluid and reflect back at a different frequency. These reflected signals shall be compared with the transmitted frequency, resulting in a frequency shift. The frequency shift shall provide an accurate measurement of the flow velocity. Fluid level shall be measured with an ultrasonic pulse echo transceiver by transmitting a sound wave to the fluid surface. The sensor shall accurately measure flows in circular and rectangular channels down to flow depths of ¼ inch. A piezoresistive pressure sensor shall be used to measure the level of fluid above the sensor if a surcharge condition occurs. In addition to the standard sensor provide a fourth sensor , an electromagnetic sensor known as a Surcharge Velocity Sensor (SVS) which allows measurement of flow velocity when the sensor becomes submerged.

2. Functional/Performance:
   a. Flow Calculation
      1) Method: Based on Continuity Equation, Q=V x A
      2) Accuracy: ±5.0% of reading typical where flow is in a channel with uniform flow conditions and is not surcharged.
   b. Velocity Measurement
      1) Method: Radar
      2) Range: 0.75 to 20 ft/s (0.23 m/s to 6.10 m/s)
      3) Accuracy: ±0.5%; ±0.1 ft/s (±0.03 m/s)
   c. Velocity Measurement-SVS (Standard sensor w/ additional EM sensor)
      1) Method: Electromagnetic
      2) Range: -5 to +20 ft/s (-1.5 to +6.1 m/s)
      3) Accuracy: 2% of reading
      4) Zero Stability: ±0.05 ft/s (±15.2 mm/s)
   d. Level Measurement
      1) Method: Ultrasonic
      2) Operating Range: 0.25 to 60 in. (0.634 to 152.4cm)
      3) Optional Operating Range: 0 (0 cm) to 224" (5.7M) with 16" dead band)
      4) Temperature Compensated
      5) Accuracy: ±0.25 in. (±0.64 cm)
      6) 1% Accuracy
   e. Surcharge Level Measurement
      1) Method: Piezo-resistive pressure transducer
      2) Maximum Range: 138 inches (3.5 meters)

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3) Operating Temperature Range: 14°F to 122°F (-10° C to 50°C); Power requirements - Match to transmitter;

3. Physical: Material: Polystyrene (IP68) rated for submerged wastewater conditions

4. Accessories/Options Required:
   a. Sensor Retrieval/Placement Pole (extends to 24 ft.)
   b. Sensor Retrieval Hook – Used with Sensor Retrieval/Placement Pole
   c. Sensor Laser Alignment Tool - Recommended to properly align sensor during installation.
   d. Sensor Mount Hardware – (Available for Permanent or Temporary Installations) Includes mounting frame and hardware to mount sensor.

C. Transmitter/Electronics

1. Type: Remote mounted, microprocessor based electronics with four lines of text display matched to flow, level, velocity, total, or any combination of any four channels containing data.

2. Functional/Performance:
   a. Power requirements - 120 VAC
   b. Temperature (ambient) -14 degrees F to 122 degrees F
   c. Output – Four 4-20 mA outputs; system-isolated, up to 600Ω load. Each output is selectable between flow, level, velocity or surcharge level. Additional dry contact closure rated for 0.5A @ 125 VAC with adjustable duration selectable for flow-proportional or alarm based on: flow, level, velocity, surcharge level, temperature, battery voltage, each sample, bad sample or analog input.

3. Physical: Housing - ABS plastic NEMA 4X rated enclosure.

D. Sensor Cable

1. The standard sensor cable shall be abrasive resistant polyurethane jacket with a waterproof connector on the sensor end and pigtail leads on the electronics end. The connector shall allow for keyed connection to the sensor. The standard flow meter shall be provided with 30 feet of cable with additional sensor cable lengths up to 1,000 feet total. Vendor to provide appropriate amount of cable based upon electrical location drawings, approximately 500 feet.

E. Manufacturer:

1. Flo-Dar with Flo-Station as manufactured by Marsh-McBirney

2. Or equal.

F. Units to be Furnished by PCSS:

1. FE/FIT 650: Process Wastewater Pump Station Flow
   a. Range: 0-7 mgd

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2.03 VANE ACTUATED FLOW SWITCH

A. Type:

1. Vane or disc actuated flow switch.

2. Switch magnetically linked to vane or disc actuated mechanism.

B. Function/Performance:

1. Output: Form 2C (DPDT) snap action, hermetically sealed switch, rated for 10 amps, 125/250 volts AC.

C. Physical:

1. Switches for pipe sizes of 3/4 to 1-1/2 inches (19 to 40 mm) shall be provided with a flowbody. Switches for pipe sizes greater than 1-1/2 inches (40 mm) shall be for installation directly in the field piping.

2. Flow body and all wetted parts shall be 316 stainless steel.

3. Switch housing shall be NEMA 4X (IP65) and where installed in hazardous areas, shall be approved for Class I, Division 1, Groups C and D (EEx d IIC T6).

D. Manufacturer(s):

1. Dwyer Flo-Tect.

2. Magnetrol F50 and F10.

3. Or equal.

E. Units to be Furnished by PCSS:

1. FSL 410-1 and -2: Equalization Pump No. 1 & 2 Seal Water Low Flow
   a. Pipe Size: 1 inch
   b. Flow Range: 0-20 gpm

2.04 ROTAMETER

A. Type: Variable area, direct reading, vane-type flowmeter.

B. Functional/Performance:

1. Function - The air or water flow moves a rotary vane in proportion to the flow rate. Vane is magnetically coupled to indicating needle.

2. Accuracy - 2 percent full scale with 10=1 range.

3. Mechanical - No gears or movements.

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C. Physical:

1. Pressure - Up to 200 psig.

2. Temperature - 32 to 250 degrees F.

3. Connections - ½-inch female NPT.

4. Materials - 316 stainless steel wetted parts, Viton O-rings, and tempered glass window; or as otherwise required for process fluid compatibility.

5. Flow Direction - Vertical, flow down.

D. Manufacturer:

1. ERDCO, Armor-Flo series.

2. Or equal.

2.05 ULTRASONIC LEVEL/DIFFERENTIAL LEVEL METER

A. Transducer

1. Type
   a. Non-contact, ultrasonic level transducer.

2. Function/Performance
   a. Measuring Range: Transducer range shall be suitable for the installation indicated on the Drawings, up to 50 ft (15m).
   b. Temperature Range: –20 to 60 degrees C.
   c. Relative Humidity: Zero to 100 percent.
   d. Temperature Compensation: Transducers shall be provided with integral temperature sensors for temperature compensation at above temperature ranges.

3. Physical
   a. Transducers shall be potted/encapsulated in a Kynar or other chemical and corrosion-resistant housing. Where indicated on the Drawings, transducers shall be approved for installation in Class I, Division 1, Groups C and D (Zone 0) environments.
   b. The surface of transducers shall be Teflon-coated where mounted on chemical tanks and exposed to vapors in the tanks that are not compatible with the transducer material.
   c. Transducers shall be capable of being completely submerged without damage.
   d. Transducers shall be suitable for surface, pipe, or flange mounting as indicated on the Drawings or Instrument Device Schedule. Appropriate mounting hardwired shall be provided. Flanges shall be six inch (150 mm) and resistant to attack by the medium being metered or, where required, shall be protected by corrosion- resistant coatings and facings.

4. Options/Accessories Required

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a. Transducers located in areas where freezing condensation may occur shall be provided with special heaters or other type of transducer protection designed to prevent sensor icing.
b. Signal cable as recommended by the manufacturer, for installation between the transducer(s) and the transmitter. Length, up to 1000 feet (300 m), shall be as required by installation indicated on the Drawings.

B. Transmitter/Converter

1. Type
   a. Microprocessor based compatible with the transducer(s) provided.

2. Functional/Performance
   a. Resolution (including transducer): Plus or minus 0.1 percent of range or 0.08 inches (2 mm), whichever is greater.
   b. Accuracy (including transducer): Plus or minus 0.25 percent of range or 0.24 inches (6 mm).
   c. Range: As required by the installation indicated on the Drawings.
   d. Temperature Range: -20 to 50 degrees C.
   e. Output: Minimum one isolated 4-20 mA output and minimum four alarm contacts (number of contacts above 4 required of each device to be determined by signals required as shown on the drawings adjustable to trip at any point in the instrument range. Output contacts shall be rated 5 A at 230 VAC.
   f. Temperature Compensation: Compensation over the temperature range of the sensor.
   g. Display: Digital indicator displaying level/differential level or volume in engineering units or percent as indicated on the Drawings or in the Instrument Device Schedule.
   h. Diagnostics: On-screen instructions and display of self- diagnostics.
   i. Loss of Signal: Transmitter shall ignore momentary loss-of-echo signals and shall indicate loss of echo on the transmitter unit.
   j. Configuration Protection: Programmable parameters shall be protected using E2PROM. Battery backup protection is not acceptable.

3. Physical
   a. Transmitter shall be suitable for surface or pipe stand mounting.
   b. Enclosure shall be NEMA 4X (IP65).
   c. Power Requirements: 120 VAC

4. Accessories Required
   a. Hand-held programmer where required for configuration and calibration of the instrument.

C. Manufacturer(s)

1. ABB

2. Endress+Hauser

3. Inventron

4. Siemens Model LUT400

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5. Or equal.

D. Units to be Furnished by PCSS:

1. LE/LIT 105: Headworks Influent Channel Level
   a. Range: 0-6 feet

2. LE/LIT 120: Headworks Effluent Channel Level
   a. Range: 0-3 feet

3. LE/LIT 405: Equalization Wetwell Level
   a. Range: 0-23 feet

4. LE/LIT 420: Equalization Tank Level
   a. Range: 0-46 feet

5. LE/LIT 1810-1 thru -3: Alum Storage Tank No. 1, 2, 3 Level
   a. Range: 0-10 feet

2.06 RF ADMITTANCE/CAPACITANCE TYPE POINT LEVEL SWITCH

A. Sensor

1. Type
   a. Rigid probe.

2. Function/Performance
   a. Range: Range and trip points shall be as indicated in the instrument device schedule.
   b. Operating Temperature: -40 to 60 degrees C.

3. Physical
   a. Probe diameters shall be 0.375 inches (9.5 mm) minimum. The probe diameter shall be as recommended by the supplier for the conditions of installation, i.e., probe length and degree of agitation in the tank.
   b. Probes shall be completely insulated. For corrosive applications, the insulating material shall be resistant to corrosion by the medium being metered. Insulating material shall be bonded to the probe.
   c. In corrosive applications, other parts exposed to the process shall also be coated for protection against corrosion.
   d. Probe assembly shall include an integral ground reference element where installed in concrete structures or non-metallic tanks. Ground reference elements shall be coated with or manufactured from materials resistant to corrosion by the medium being metered.
   e. Probe mounting shall be a four-inch (100 mm), 150 pound, 316 stainless steel flange for non-corrosive applications. Flanges for corrosive applications shall be of materials resistant to corrosion by the medium being metered, or shall be protected by corrosion- resistant coatings and facings.
   f. Where required for installation in hazardous areas, probes shall be intrinsically safe, approved for installation in Class I, Division 1, Groups C and D (Zone 0).

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B. Converter/Relays

1. Type
   a. Integrally mounted electronic converter and multiple relays.

2. Functional/Performance
   a. System Accuracy: Plus or minus one percent of span.
   b. Operating Temperature: -40 to 60 degrees C.
   c. Output: 5 A, 120 VAC contacts for the number of switching points indicated on the drawings.
   d. Power Supply: 120VAC
   e. Coating Effects: The electronics shall include circuitry to render the sensing element unaffected by coatings, foam, or other materials that may build up on the probe.
   f. Electronics shall be immune to RFI/EMI noise.

3. Physical
   a. Housing (including indicator): NEMA 4 (IP65) for non-hazardous locations and explosion-proof, approved for Class I, Division 1, Groups C and D service (EEx d IIC) where indicated on the Drawings to be installed in a hazardous area.

C. Manufacturer(s)

1. Ametek Drexelbrook Multipoint II.

2. Or equal.

D. Units to be Furnished by PCSS:

1. LSHH/LSLL 1810-1 thru -3: Alum Storage Tank No. 1, 2, 3 High-High/Low-Low Level
   a. LSHH: 1 ft from tank bottom
   b. LSLL: 1 ft from tank top

2.07 FLOAT SWITCH (PROCESS)

A. Type

1. Mercury free ball float switch.

B. Function/Performance

1. Differential: Less than 8 inch.

2. Switch Rating: 1 amps at 120 VAC or 100 VA @ 120 VAC

3. Provide NO or NC type contact for fail-safe operation per section 13300-2.01.F or as shown on the drawings.

C. Physical

1. Float: 316 stainless steel, Teflon or non-stick coating, minimum 5 in diameter.

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2. Totally encapsulated switch.

3. Cable shall be heavy-duty, PVC or equivalent jacketed integral to float.

D. Options/Accessories Required

1. Provide mounting hardware as shown on the Detail Drawing.

2. Lead wire shall be a waterproof cable of sufficient length so that no splice or junction box is required inside the vessel.

3. Provide a weatherproof junction box outside the vessel with terminals for all floats and tapped as required for conduit connections.

E. Manufacturer(s)

1. Siemens Water Technologies Model 9G-EF.

2. Contegra FS 90

3. Or equal.

F. Units to be Furnished by PCSS:

1. LSHH 105: Headworks Influent Channel High-High Level
   a. Elevation: 662.50’

2. LSHH 420: Equalization Tank High-High Level
   a. Elevation: 676.50’

2.08 FLOAT SWITCH (CONTAINMENT)

A. Type

1. Hermetically sealed magnetic reed switch sealed within a float, mounted on a vertical stem.

B. Function/Performance

1. Actuation distance: approximately 1 inch.

2. Switch: 25 VA; 1 A @ 220 VAC, normally open contacts.

C. Physical

1. Wetted Materials: 316SS, Teflon, polypropylene, or otherwise as required for chemical compatibility.

2. Totally encapsulated switch.

3. Cable shall be heavy-duty, PVC or equivalent jacketed integral to float.

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D. Options/Accessories Required

1. Provide stainless steel bracket and hardware to mount the switch. Height shall be such that the float actuates approximately 3 inches above the floor of the containment area.

2. Lead wire shall be a waterproof cable of sufficient length so that no splice or junction box is required inside the containment area.

3. Provide a weatherproof junction box outside the containment area with terminals for all floats and tapped as required for conduit connections.

E. Manufacturer(s)

1. Dwyer F6/F7 Vertical.

2. Or equal.

F. Units to be Furnished by PCSS:

1. LSH 1800: Alum Containment High Level
   a. Elevation: approximately six inches above the containment area floor.

2.09 PRESSURE TRANSMITTERS

A. Type:

1. Microprocessor based, intelligent type.

2. Gauge or Differential type as needed for the application.

B. Function/Performance:

1. Range: Range of the transmitter shall be the standard range of the manufacturer closest to the differential pressure range to be metered.

2. Accuracy: 0.075 percent of span (linear output) or better.

3. Operating Temperature: -20 to 80 degrees C.

4. Temperature Effect: Combined temperature effects shall be less than 0.2 percent of maximum span per 28 degrees C temperature change.

5. Static Pressure Effect: Effect on accuracy due to static pressure changes shall be negligible.

6. Output: 4-20 mA DC adjustable over the instrument range, with HART protocol. Output shall be linear for differential pressure applications. For flow metering applications, the output shall be proportional to the square root of the input differential pressure.

7. Stability: 0.1 percent of upper range limit for 1 year.

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8. Display:
   a. Digital indicator displaying differential pressure or flow in the engineering units indicated in the Instrument Device Schedule.

9. Diagnostics:
   a. Self-diagnostics with transmitter failure driving output to above or below out of range limits.
   b. Simulation capability for inputs and loop outputs.
   c. Test terminals available to ease connection for test equipment without opening the loop.
   d. Registers to record minimum and maximum pressure and temperatures transmitter has been exposed to shall be available.

10. Over Range Protection: Provide positive over range protection to 150 percent of the maximum pressure of the system being monitored by the instrument.

C. Physical:

1. Enclosure: NEMA 4X (IP66), explosion proof, approved for Class I, Division 1, Groups C and D (EEx d IIC T5).

2. Process Wetted Parts: Isolating diaphragm and other wetted metal parts shall be 316L stainless steel, unless otherwise indicated in the device schedule. Gaskets and O rings shall be Teflon.

3. Power Supply: 24 VDC loop power.

4. Sensor Fill Fluid: Silicone.

D. Accessories Required:

1. Provide span and zero adjustment at each transmitter and through the handheld programming unit.

2. For each transmitter provide a three valve manifold. The manifold shall be 316 stainless steel. Manifolds may be mounted directly to the instrument or separately mounted. Manifolds shall be by the instrument manufacturer or by D/A Manufacturing or Anderson Greenwood.

E. Manufacturer(s):

1. ABB 264DS

2. Rosemount 2051 or 3051 series

3. Siemens Sitrans P DS III

4. Or equal.

F. Units to be Furnished by PCSS:

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1. PIT : Reclaimed Pump No. 5 Discharge Pressure
   a. Range:

2.10 PRESSURE SWITCH

A. Type:

1. Diaphragm or bellows type.

2. Gauge or Differential service as required.

B. Function/Performance:

1. Repeatability: Better than 1 percent of full scale.

2. Setpoint: Field adjustable and set between 30 and 70 percent of the adjustable range.

3. Dead Band: Fixed unless adjustable dead band requirement is noted in the Instrument Device Schedule.

4. Reset: Unit shall be of the automatic reset type unless noted otherwise in the Instrument Device Schedule.

5. Over Range Protection: Over range protection to 150 percent of the maximum process line pressure.

6. Output: Single pole double throw (SPDT) unless requirement for double pole double throw (DPDT) switch is shown on the instrument device schedule. Switch rating shall be 10 A at 230 VAC.

C. Physical:

1. Housing: NEMA 4X (IP65) for non-hazardous areas. For installation in hazardous areas, housing shall be explosion proof approved for Class 1, Division 1, Groups C and D (EEx d IIB).

2. Switch Assemblies: Hermetically sealed switches.

3. Wetted Parts: 316L stainless steel diaphragm, viton seals, 316 stainless steel connection port.

D. Accessories/Options Required:

1. Shutoff Valve: Provide a 316 stainless steel shutoff valve. Valve shall be by D/A Manufacturing, Anderson Greenwood, or Equal.

2. Where indicate on the instrument device schedule, provide a 316 SS snubber for pulsation dampening.

E. Manufacturer(s):

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1. Static-O-Ring (SOR).

2. Ashcroft.

3. Mercoid.

4. Or equal.

F. Units to be Furnished by PCSS:

1. PSH 410-1 and -2: Equalization Pump No. 1 & 2 High Discharge Pressure
   a. Setpoint: 27 psig

2. DPSH 203 and 204: Oxidation Blower No. 3 & 4 Intake Filter High Differential Pressure
   a. Setpoint: between 0 and 1 psid

3. PSL 1865-1 thru -6: Alum Metering Pump No. 1-6 Low Suction Pressure
   a. Setpoint: between 0 and 2 psig

4. PSH 1870-1 thru -6: Alum Metering Pump No. 1-6 High Discharge Pressure
   a. Setpoint: between 50 and 60 psig

2.11 PRESSURE GAUGE

A. Type:

1. Bourdon tube actuated dial face pressure gauge.

B. Function/Performance:

1. Accuracy: Plus or minus 1.0 percent of span or better.

C. Physical:

1. Case: Phenolic shock resistant or type 316 stainless steel for surface/stem mounting with a pressure relieving back. The case shall be vented for temperature/atmospheric compensation. Gauge shall be callable of being liquid filled in the field or at the factory.

2. Window: Clear acrylic or shatter proof glass.

3. Bourdon tube: Stainless steel.

4. Connection: 1/2 in. NPT.

5. Gauge size: Minimum 4-in. viewable.

6. Pointer travel: Not less than 200 degrees not more than 270-degree arc.

7. Range: As indicated in the instrument device schedule. Range may include inches of water vacuum.

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D. Accessories/Options Required:

1. Shutoff valve: Each gauge shall have a process shutoff valve that can also be used as an adjustable pressure snubber.

2. Special scales: Engineer reserves the right to require special scales and/or calibration if the manufacturer's standard is not suitable for the application.

3. Gauges listed as liquid filled in the instrument device schedule shall be liquid filled at the factory.

E. Manufacturer(s):

1. Ashcroft

2. Trerice

3. Or equal.

F. Units to be Furnished by PCSS:

1. PI 410-1A and -2A: Equalization Pump No. 1 & 2 Suction Pressure
   a. Range: 0-20 psig

2. PI 410-1B and -2B: Equalization Pump No. 1 & 2 Discharge Pressure
   a. Range: 0-40 psig

3. PI 1865-1 thru -6: Alum Metering Pump No. 1-6 Suction Pressure
   a. Range: 0-5 psig

4. PI 1870-1 thru -6: Alum Metering Pump No. 1-6 Discharge Pressure
   a. Range: 0-100 psig

2.12 DIAPHRAGM SEAL - THREADED

A. Type:

1. Thread attached.

2. Welded Metal Diaphragm.

B. Function/Performance:

1. Maximum Pressure: Two times the maximum process pressure.

2. Operating Temperature: -40 to 100 degrees C.

C. Physical:

1. All 316L stainless steel construction.

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2. Teflon gaskets and O rings on process connection.

3. Bleeding connection provided. NOTE: filling screw not recommended since it provides poor quality measurement if done incorrectly in the field.

D. Accessories Required:

1. Stainless steel armored capillary tubing as required for the installation.

E. Manufacturer(s):

1. Rosemount.

2. Ashcroft.

3. Ronningen-Petter Company.

4. Siemens 7MF4861

5. Or equal.

F. Units to be Furnished by PCSS: As shown on Drawings associated with pressure instruments.

2.13 AMMONIA ANALYZER – IN-SITU

A. Type:

1. Continuous measurement of total ammonia via an in-situ analyzer. Measuring principle shall be an ammonium (NH_4^+) sensing ion-selective electrode probe. Analyzer shall incorporate pH, temperature, and potassium (K^+) compensation over its entire range of detection to ensure accurate readings of the total ammonia (NH^+_4 and NH_3) in solution.

B. Function and Performance:

1. Measuring Range: 0.1 to 1000 mg/l, NH_4-N.

2. Accuracy: 3% ± 0.1 mg/l, whichever is greater.

3. Minimum Detection Limit: 0.05 mg/l.

4. Response Time: 60 seconds.

5. Operating Temperature: 0 to 40 °C.

6. Operating Pressure: 0 to 400 mbar.

7. Sample Flow Rate: 0.01 m/s minimum.

C. Physical:

1. Stainless steel housing.

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D. Transmitter:

1. Include compatible remote-mounted transmitter by same manufacturer as specified elsewhere in this section.

E. Accessories Required:

1. Sensor cable.

2. 1 year supply of consumables.

F. Manufacturer:

1. s::can – ammo::lyser pro.

2. WTW – AmmoLyt Plus.

3. Hach – NH4D sc

4. Or equal.

G. Units to be Furnished by PCSS:

1. AE/AIT 215: Oxidation Basin No. 2
   a. Range: 0-25 mg/L

2. AE/AIT 216: Oxidation Basin No. 1
   a. Range: 0-25 mg/L

3. AE/AIT 217: Oxidation Basin No. 3
   a. Range: 0-25 mg/L

2.14 SUSPENDED SOLIDS ANALYZER

A. Type:

1. Microprocessor-based MLSS or TSS suspended solids analyzer.

2. Multi-sensor transmitter where required.
   a. In some locations, multiple probes shall be connected to multiple channels of a single transmitter. Note transmitter may have dual functions (i.e measure NO3 and pH). Functions are listed separately in this specification. Refer to the Drawings for specific requirements per location.

3. Inline or in-situ probe sensor as required.

B. Functional/Performance:

1. Operation: Phased-array light source and photo detector combination measures suspended solids content of process water, which is indicated and transmitted by the analyzer.

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2. Accuracy: ± 5% of reading or ± 100 mg/L, whichever is greater.

3. Repeatability: ± 1% of reading or ± 20 mg/L, whichever is greater.

4. Output: 4-20mA proportional to process value span.

5. Display: Backlit LCD display for local operation. The reading shall be displayed in engineering units.

6. Calibration: User-selectable linearization curves and auto-ranging.

7. Diagnostics: Built-in diagnostics will detect at least the following faults: sensor light detector failure, abnormal calibration, internal program failure.

8. Power: 120VAC, 60 Hz.

9. Mounting: Bracket and pole shall be provided to hold the sensing probes in the process fluid. Bracket shall permit easy withdrawal from service for inspection and maintenance.

C. Physical:

1. Sensor Pressure/Temperature: 0-50 psig / 0-50 deg. C.

2. Sensor Mounting: Furnish hot-tap ball valve assembly and strapping for inline mounting, as required.

3. Analyzer Enclosure: NEMA 4X / IP65 rated.

4. Analyzer Mounting: Provide brackets as needed for wall or pipe mounting.

5. Cable: Furnish connector cable between sensor and analyzer, length as needed.

D. Manufacturer:

1. Cerlic ITXIL / BB2

2. Or equal.

E. Units To Be Supplied By ISS:

1. AE/AIT 207: Oxidation Basin No. 2
   a. Range: 0-5000 mg/L

2. AE/AIT 208: Oxidation Basin No. 1
   a. Range: 0-5000 mg/L

3. AE/AIT 209: Oxidation Basin No. 3
   a. Range: 0-5000 mg/L

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2.15 TOXIC GAS DETECTOR

A. Sensor:

1. Type:
   a. Electrochemical type sensor.

2. Function/Performance:
   a. Operating Range: 32 to 104 °F.

3. Physical:
   a. Suitable for remote mounting up to 1000 ft. (305 m) from the receiver.
   b. NEMA 4X housing.

4. Accessories Required:
   a. Sufficient cable as recommended by the manufacturer for installation between sensor and transmitter.
   b. Sensors shall be fitted with a splash guard to prevent accidental wetting.

B. Remote Indicating Transmitter/Controller:

1. Type:
   a. Microprocessor-based compatible with sensor provided.
   b. Single channel.

2. Function/Performance:
   a. Linearity: ± 10 percent of full scan or 2 ppm.
   b. Repeatability: ± 4 percent of full scan or 2 ppm.
   c. Range: 0 to 10 ppm.
   d. Operating Temperature: 32 to 104 °F.
   e. Output: Two alarm contacts rated for 5A at 240 VAC, individually configurable over the range of the transmitter.
   f. Display: LED indicators for display of alarm conditions.

3. Physical:
   a. Suitable for surface mounting.
   b. NEMA 4X enclosure.
   c. Power Requirements: 7 to 30 VDC. PCSS is responsible for furnishing separate 24VDC power supply in locations where only 120VAC is available.

4. Accessories Required:
   a. One year supply of calibration and test gas for the number of detectors indicated on the Drawings or in the Instrument Device Schedule.
   b. One calibration kit including calibrator, fittings, hoses, and other components required for detector calibration.
   c. In lieu of the above, if the vendor offers a "Sensor Exchange" program as a standard offering, a year of this Sensor Exchange program is acceptable. This program shall deliver a freshly calibrated sensor at manufacturer recommended calibration intervals for replacement of the existing sensor. All information shall be uploaded to the

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transmitter for the new sensor with no further maintenance required for the new sensor to function properly.

C. Manufacturer(s):

1. MSA Ultima XA Series.

2. Dräger PointGard II.

3. Industrial Scientific iTrans.

4. Sensidyne SensAlert Plus.

5. Or equal.

D. Units to be Furnished by PCSS:

1. AE/AIT 421: Equalization Tank Hydrogen Sulfide

2.16 COMBUSTIBLE GAS DETECTOR

A. Sensor:

1. Type:
   a. Intrinsically safe.
   b. Continuous infrared sensor.

2. Function/Performance:
   a. Response Time: T90 in less than 30 seconds.
   b. Sensor Life: 3 years typical.

3. Physical:
   a. Infrared sensor technology.
   b. Suitable for remote wall or ceiling mounting, or directly fitted to transmitter.

4. Accessories Required:
   a. Sufficient cable up to 50 ft (15 m) of the type recommended by the manufacturer shall be provided for installation between sensor and transmitter as required by the installation indicated on the Drawings.
   b. Remote sensor enclosures shall be explosion proof, approved for Class 1, Division 1, Groups C and D (EEx d IIC T4) areas.
   c. Detectors that are mounted below 6 ft (2 m) above floor level shall be fitted with splash guards supplied by the manufacturer, to protect the sensor from accidental wetting.
   d. Where indicated, provide air sampling equipment, including compressor, polyethylene tubing, and moisture filter, to withdraw air samples from hazardous areas while mounting the sensor assembly outside.

B. Remote Indicating Transmitter/Controller:

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1. Type:
   a. Electronic, microprocessor based single channel transmitter compatible with sensor provided.

2. Function/Performance:
   a. Accuracy: ± 3 percent up to 50 percent LEL, ±5 percent for greater than 50 percent LEL.
   b. Range: 0 to 100 percent LEL.
   c. Environmental Conditions: -20 to 60 degrees C; 10 to 95 percent relative humidity.
   d. Power Requirements: 7 to 30 VDC. PCSS is responsible for furnishing separate 24VDC power supply in locations where only 120VAC is available.
   e. Output: One 4-20 mA output proportional to calibrated range. Two programmable relay contacts for warning, alarm, and/or fault.
   f. Display: Digital display indicating the gas level, alarm or fault messages, and diagnostic information.

3. Physical:
   a. Explosion proof enclosure approved for Class 1, Division 1, Groups B, C, and D (EEx d IIC T4).
   b. Suitable for surface mounting.

4. Accessories Required:
   a. Handheld programming unit if required for setup and calibration.

C. Manufacturer(s):

1. MSA Ultima XIR Series.

2. Industrial Scientific iTrans.

3. Dräger Polytron 2 XP Ex.

4. Sensidyne SensAlert Plus.

5. Or equal.

D. Units to be Furnished by PCSS:

1. AE/AIT 105: Headworks Influent Channel Combustible Gas

2. AE/AIT 155-1: Vortex Grit No. 1 Combustible Gas

3. AE/AIT 155-3: Vortex Grit No. 3 Combustible Gas

4. AE/AIT 155-4: Vortex Grit No. 4 Combustible Gas

5. AE/AIT 155-5: Grit Influent Channel Combustible Gas

6. AE/AIT 180: Headworks Odor Control Area Combustible Gas

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7. AE/AIT 420: Equalization Tank Combustible Gas

8. AE/AIT 450: Equalization Odor Control Area Combustible Gas

2.17 LIMIT SWITCH

A. Type:

1. Direct opening 2 position snap action.

B. Function/Performance:

1. Minimum 2 double pole single throw (DPST) NO contacts or 2 double pole double throw (DPDT) contacts.

C. Physical:

1. Lever or button style spring return actuator.

2. Contact rating for 120 VAC/30 VDC, 100VA minimum.

D. Accessories/Options Required:

1. Non-corrosive, NEMA 4X.

2. If a sealed pre-wired switch is used, a separate connection or junction box of equal environmental protection rated will be supplied and installed.

E. Manufacturer(s):

1. Allen-Bradley.

2. Square D.

3. Or equal.

F. Units to be Furnished by PCSS:

2.18 SPARE PARTS AND ACCESSORIES

A. General requirements for spare parts are specified in Section 13300.

B. The following field Instrument related Spare Parts shall be furnished:

1. One pressure switch for each type or range provided.

2. One pressure gauge for each type or range provided.

3. Gas detector spares and consumables as recommended by the manufacturer.

C. The following accessories shall be furnished:

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1. All mounting hardware required for pipe stand, surface, or other mounting shall be provided.

2. Each instrument shall be provided with a manufacturer installed stainless steel tag identifying the instrument tag number.

PART 3 EXECUTION

3.01 GENERAL

A. See execution requirements in Section 13300.

B. Unless specifically indicated, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, 5-valve manifolds for calibration, testing and blow down service shall also be provided. For chemical or corrosive fluids, diaphragm seals with flushing connections shall be provided.

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SECTION 15051
PIPING - GENERAL REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the basic administrative and testing requirements for non-buried piping. Specific piping materials, systems and related installation and testing requirements are specified in other Sections of Division 15.

1.02 RELATED WORK

A. Pipeline testing, cleaning and disinfection are included in Section 01445.

B. Buried piping and appurtenances are included in Division 2.

C. Non-buried piping materials and systems are included in other Sections of Division 15.

D. Valves are included in Section 15100.

E. Piping specialties are included in Section 15120.

F. Pipe hangers and supports are included in Section 15140.

G. Thermal insulation is included in Section 15250.

H. Electric heat tracing is included in Section 15257.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, general submittals for piping and piping systems as listed below. It is not intended that all submittals listed below be provided for all piping materials and systems. Refer to individual System or Piping Sections for specific submittals.

B. Shop Drawings and Product Data

1. Piping layouts in full detail.

2. Location of pipe hangers and supports.

3. Location and type of backup block or device to prevent joint separation.

4. Large scale details of wall penetrations and fabricated fittings.

5. Schedules of all pipe, fittings, special castings, couplings, expansion joints and other appurtenances.

6. Catalog cuts of joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.

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7. Brochures and technical data on coatings and linings and proposed method for application and repair.

C. Samples

D. Design Data

E. Test Reports

1. Four copies of certified shop tests showing compliance with appropriate standard.

2. Four copies of all field test reports, signed by Contractor and Engineer.

F. Certificates

1. Copies of certification for all welders performing work in accordance with ANSI B31.1.

G. Manufacturers Installation (or application) instructions.

H. Statement of Qualifications

I. Manufacturer's Field Report

J. Project Record Documents in accordance with Section 01720.

K. Operation and Maintenance Data in accordance with Section 01730.

L. Warranties in accordance with Section 01740.

1.04 REFERENCE STANDARDS

A. ASTM International

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

B. American National Standards Institute (ANSI)

1. ANSI B16.5 - Pipe Flanges and Flanged Fittings

2. ANSI B31.1 - Power Piping

C. American Welding Society (AWS)

1. AWS B2.1 - Specification for Welding Procedure and Performance Qualifications

D. American Water Works Association (AWWA)

1. AWWA Manual M11 - Steel Pipe - A Guide for Design and Installation

E. American Society of Mechanical Engineers (ASME)

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F. Underwriters Laboratories (UL)

G. Factory Mutual (FM)

H. 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 materials shall be new and unused.

B. Install piping to meet requirements of local codes.

C. Provide manufacturer's certification that materials meet or exceed minimum requirements as specified. Reference to standards such as ASTM and ANSI shall apply to those versions in effect at the time of bid opening.

D. Coordinate dimensions and drilling of flanges with flanges for valves, pumps and other equipment to be installed in piping systems. Bolt holes in flanges to straddle vertical centerline.

E. Reject materials contaminated with gasoline, lubricating oil, liquid or gaseous fuel, aromatic compounds, paint solvent, paint thinner and acid solder.

F. Pipe-joint compound, for pipe carrying flammable or toxic gas, must bear approval of UL or FM.

G. Unless otherwise specified, pressures referred to in all Piping Sections are expressed in pounds per square in gauge above atmospheric pressure, psig and all temperature are expressed in degrees Fahrenheit (F).

1.06 DELIVERY, STORAGE AND HANDLING

A. During loading, transportation and unloading take care to prevent damage to pipes and coating. Carefully load and unload each pipe under control at all times. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to ensure no injury to pipe and lining.

PART 2 PRODUCTS

2.01 MATERIALS

A. Specific piping materials and appurtenances are specified in the respective Piping or System Sections.

B. General installation materials shall be as specified below.

1. Unions shall be brass or bronze unions for joining nonferrous pipe; malleable brass or bronze-seated iron or steel unions for joining ferrous pipe; PVC unions for joining PVC pipe; CPVC unions for joining CPVC pipe.

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2. Flanged Joints. Bolt and nuts, Type 304 stainless steel, bolt number and size same as flange standard; studs - same quality as machine bolts; 1/16-in thick rubber gaskets with cloth insertions; rust-resistant coatings.

3. Temporary Plugs shall be standard plugs or caps which are suitable for permanent service.

4. Wall Sleeve Seals shall be as specified in Section 01172.

5. Flexible connections shall be as specified in Section 15120.

C. In the event of a conflict between this Section and the requirements of a piping Section, the requirements of the piping Section shall govern.

PART 3 EXECUTION

3.01 GENERAL

A. All dirt, scale, weld splatter, water and other foreign matter shall be removed from the inside and outside of all pipe and sub-assemblies prior to installing.

B. All pipe joints and connections to equipment shall be made in such a manner as to produce a minimum of strain at the joint.

C. 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 recognized methods and procedures of pipe fabrication and in accordance with the latest revision of applicable ANSI Standards, ASME Codes and Pipe Fabrication Institute Standards.

1. Use full length of pipe except where cut lengths are necessary. Do not spring or deform piping to make up joints.

2. Pipe shall be cut square, not upset, undersize or out of round. Ends shall be carefully reamed and cleaned before being installed.
   a. Bending of pipe is not permitted. Use fittings for all changes in direction.

3. 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.

4. 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.

5. Where lines of lower service rating tie into services or equipment of higher service rating the isolation valve between the two shall conform to the higher rating.

6. Mitering of pipe to form elbow is not permitted.

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7. 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 should be suitable to withstand the hydrostatic test.

8. 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.

D. 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.

E. Unions

1. Unions, screwed or flanged, 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.

F. Vents and Drains

1. Provide vents and drains in the following places:
   a. Water Lines - Vents at high points and drains at low points.
   b. Air Lines - Drains at low points.

3.02 UNIONS

A. Use unions to allow dismantling of pipe, valves and equipment.

3.03 WELDING

A. Welding shall be in accordance with ANSI B31 and AWS B3.0.

B. Install welding fittings on all welded lines. Make changes in direction and intersection of lines with welding fittings. Do not miter pipes to form elbows or notching of straight runs to form tees, or any similar construction. Do not employ welder who has not been fully qualified in above specified procedure and so certified by approved welding bureau or similar locally recognized testing authority.

3.04 FLANGED JOINTS

A. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped. Use number and size of bolts conforming to same ANSI Standard as flanges. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces,

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clean gaskets and smooth all burrs and other defects. Make up flanged joints tight, care being taken to prevent undue strain upon valves or other pieces of equipment.

3.05 SLEEVE COUPLINGS

A. Install tierods, pipe clamps or bridles when sleeve type couplings or fittings are used in piping system where indicated, and at changes in direction or other places as necessary, to prevent joints from pulling apart under pressure. Use bridles and tierods at least 3/4-in in diameter, except where tierods replace flange bolts of smaller size, in which case fit with nut on each side of pair of flanges. Joint harnessing shall conform, as a minimum, to the requirements for the bolts and tie bolt lugs as set forth in AWWA Manual M11.

3.06 WALL SLEEVE SEALS

A. Use expandable rubber segmented sealing device with corrosion-resistant fasteners to make watertight the annular space between pipe and sleeve. Determined the required inside diameter of each individual wall opening or sleeve to fit the pipe and seal it to assure a watertight joint as recommended by the manufacturer, before ordering, fabricating or installing. Install pipe concentrically through wall sleeve. Install and tighten seal per manufacturer's instructions.

3.07 TESTING

A. Test all pipelines for water/gas tightness as specified in the Piping or System sections. Furnish all labor, testing plugs or caps, pressure pumps, pipe connections, gauges and all other equipment required. Testing shall be performed in accordance with one or more of the testing procedures appended to this Section as specified in each Piping or System Section. All testing shall be performed in the presence of the Engineer.

B. Test pressures and procedures shall be as specified in Section 01445.

C. Repair faulty joints or remove defective pipe and fittings and replace as approved by the Engineer. Retest.

3.08 DISINFECTION

A. After satisfactory testing, all potable and protected water collection and distributed systems shall be thoroughly disinfected in accordance with Section 01445.

END OF SECTION

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SECTION 15061
STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install all non-buried steel pipe and appurtenances as shown on the Drawings and as specified herein.

B. Steel pipe shall include black steel and galvanized steel pipe with fittings, flanges, and unions, complete with coatings, wrappings, linings, and painting.

1.02 RELATED WORK

A. Pipeline testing, cleaning and disinfection is included in Section 01445.

B. Steel pipe sleeves are included in Section 01172.

C. Buried pipe and appurtenances are included in Division 2.

D. Concrete work is specified in Division 3.

E. Field painting, except as specified herein, is included in Section 09902.

F. Piping – General Requirements is included in Section 15051.

G. Stainless steel pipe and fittings are included in Section 15066.

H. Valves and appurtenances are included in Section 15100.

I. Piping specialties are included in Section 15120.

J. Pipe hangers and supports are included in Section 15140.

K. Pipe insulation is included in Section 15250.

L. Electric heat tracing is included in Section 15257.

M. Piping pertaining to Plumbing and HVAC is included in Sections 15400 and 15500, respectively.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, working drawings, shop drawings, and material specifications including the following:

1. A list of materials to be furnished, the names of the suppliers, and the date of delivery of materials to the site.

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2. Complete shop drawings of all components detailing materials, conformance to standards, dimensions, and design pressure ratings.

3. Fully dimensioned layout and cross section drawings of pipelines locating jointing, fittings, couplings, sleeves, expansion joints, supports, anchors, harnessing, valves, and equipment. Pipe size, type, and materials shall be labeled on the drawing.

4. Complete schedule of all components included in the pipeline drawings, indicating the material and schedule number of thickness of all pipe, the materials and class of all fittings and valves.

5. Details of pipe coating, wrapping, lining, and painting.

6. Certification of pipe design to the criteria specified herein.

7. Certification of qualifications of all welders to perform shop and field welding of piping.

1.04 REFERENCE STANDARDS

A. National Sanitation Foundation (NSF)

1. 61 – Drinking Water System Components – Health Effects

B. ASTM International

1. ASTM A47 - Ferritic Malleable Iron Castings.

2. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

3. ASTM A105 - Carbon Steel Forgings, for Piping Applications.

4. ASTM A126 – Gray Iron Casting for Valves, Flanges, and Pipe Fittings

5. ASTM A139 – Electric-Fusion (ARC)-Welded Steel Pipe

6. ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

7. ASTM A193/A193M – Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

8. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

9. ASTM A283/A283M – Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars

10. ASTM A307 - Carbon Steel Bolts and Studs 60,000 psi Tensile Strength.

11. ASTM A714 - Standard Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe.

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C. ANSI/ASME

1. ANSI/ASME B1.1 – Unified Inch Screw Threads (UN and UNR Thread Form)
2. ANSI/SAME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings
3. ANSI/ASME B16.3 – Malleable-Iron Screwed Fittings, 125 and 150 lb
4. ANSI/ASME B16.4 – Cast Iron Threaded Fittings
5. ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings
6. ANSI/ASME B16.9 - Factory-Made Wrought Steel Buttwelding Fittings
7. ANSI/ASME B16.11 – Forged Steel Fittings, Socket-Welding and Threaded
8. ANSI/ASME B16.21 – Non-Metallic Gaskets and Pipe Flanges
9. ANSI/ASME B18.2.1 – Square and Hex Bolts and Screws
10. ANSI/ASME B31.1 – Power Piping
11. ANSI/ASME B36.10M – Welded and Seamless Wrought Steel Pipe

D. American Water Works Association (AWWA)

1. ANSI/AWWA C200 – Steel Water Pipe 6 Inches and Larger
2. ANSI/AWWA C203 – Coal-Tar Protective Coatings and Linings for Steel Water Pipelines – Enamel and Tape – Hot-Applied
3. ANSI/AWWA C205 – Cement-Mortar Protective Lining and Coating for Steel Water Pipe – 4 Inch and Larger – Shop Applied
4. ANSI/AWWA C206 – Field Welding of Steel Water Pipe
5. ANSI/AWWA C207 – Steel Pipe Flanges for Waterworks Service – Size 4 Inch through 144 Inch
6. ANSI/AWWA C208 – Dimensions for Fabricated Steel Water Piping Fittings
7. ANSI/AWWA C210 – Liquid Epoxy Coating Systems for Interior and Exterior of Steel Water Pipelines
8. ANSI/AWWA C214 – Tape Coating Systems for the Exterior of Steel Water Pipelines
9. ANSI/AWWA C602 - Cement-Mortar Lining of Water Pipelines - 4 In. (100 mm) and Larger - in Place
10. ANSI/AWWA C651 - Disinfecting Water Mains

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11. AWWA M11 – Steel Pipe – A Guide for Design and Installation

E. American Welding Society (AWS)

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 steel pipe and fittings shall be furnished by manufacturers who are fully experienced, reputable and qualified in the manufacture of the items to be furnished. The equipment shall be designed, constructed and installed in accordance with the applicable standards of ASTM, ANSI and AWWA as specified herein.

B. Utilize only certified welders, having current certificates conforming to the requirements of the ASME code to perform all welding on steel pipes. Welders shall be qualified under the requirements of Section IX Welding Qualifications, of the ASME Boiler and Pressure Vessel Code.

C. The manufacturer's name or trademark, the year of manufacture, and the specification to which the pipe is manufactured shall be rolled, permanently inscribed, or stenciled on the pipe surface at the manufacturer's plant. Pipe 1-1/2 inches and less in nominal diameter shall be bundled and tagged.

D. The Engineer reserves the right to perform shop inspections of the manufacture of the pipe. Provide at least 30 days notice to the Engineer prior to the beginning of any work so that inspection may be arranged. Furnish all facilities required for the inspection of materials and workmanship in the shop. Inspectors shall be allowed free access to the necessary parts of the facility for inspections.

1. Inspection may include, but not be limited to, welding inspection, review of certified material test reports, traceability check, and witness of assembly and fit-up. Prior to manufacture, the pipe fabricator shall supply the following information on suppliers of plate, piping, and other components: Items(s) furnished, company name and address, contact name, telephone and fax number. The Engineer reserves the right to visit any or all of the suppliers and conduct inspections at their facilities.

2. The inspector shall have the authority to reject any material or work that does not meet the requirements of the Contract Documents.

3. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from the responsibility for furnishing proper materials or workmanship.

4. The costs of all welding supervision and inspections and tests shall be borne by the Contractor. The Contractor shall engage inspectors to inspect welded connections and to perform tests and prepare test reports. Welds shall receive non-destructive testing as required by the specification under which the pipe is manufactured.

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5. Welds that are required to be corrected shall be corrected or redone and retested at the Contractor's expense and to the satisfaction of the Engineer and/or an acceptable independent testing lab.

6. Submit certified materials test reports indicating physical and mechanical properties and heat treatment for all piping components.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Pipe, fittings, and appurtenances shall be delivered, stored, and handled in accordance with the provisions of Division 1, and as follows:

B. When require for maintaining its circular shape and preventing distortion, each length of pipe shall be temporarily braced with an approved type of internal spider in each end of the pipe during handling and installation.

C. Coated pipe shall be protected at all times and handled with equipment designed to prevent damage to the coatings and linings, such as stout wide canvas slings and wide padded skids. The use of bare chains, cables, hooks, metal bars or narrow skids in contact with the coating will not be permitted. Pipes shall be separated so that they do not bear against each other. During transit, pipes shall be securely fastened to their transport skid to prevent movement. Provide for prompt and efficient repair of all abrasions and injuries to pipe coatings and linings.

1.07 SYSTEM DESCRIPTION

A. Steel piping shall be installed in the locations shown on the Drawings.

B. The equipment and materials specified herein are intended to be standard types of steel pipe and fittings for use in transporting water, wastewater, residuals, air, and chemical solutions.

C. Steel piping systems listed below shall be designed for the following conditions:

System:	Plant Effluent
Material:	[ASTM _____ Schedule __] [AWWA C200]
Fluid:	Plant Effluent Water
Pressure:	
Normal:	____ psi
Test:	____ psi
Temperature:	Ambient to ___ degrees F
Lining	[Cement Mortar] [Epoxy]
Special Conditions:	[Insulation]
System:	Low Pressure Air
Material:	Copper nickel steel ASTM A714
Fluid:	
Air Pressure:	
Normal:	__ psi
Test:	__ psi
Flow Velocity:	_____ fpm (maximum)
Temperature:	Ambient to ___ degrees F
Special Conditions:	Blower vibration

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PART 2 PRODUCTS

2.01 PIPE

A. Steel pipe through 24 inch diameter shall conform to ASTM A-53. Where indicated on the Drawings to be galvanized, pipe shall be hot-dipped galvanized after fabrication.

B. Steel pipe 30 inch diameter and larger shall conform to AWWA C200 and fabricated of plates meeting the requirements of ASTM A283/A283M, [Grade C][Grade D], or ASTM A139, Grade A, having a minimum yield strength of 30,000 psi, fusion welded in accordance with the Code for Pressure Piping, ASME B31.1, to develop full plate strength. Pipe shall conform to dimensions for steel pipe in accordance with ASME B36.10M. Pipe shall be fabricated with straight-seam welds or spiral-seam welds with smooth uniform cross section to provide pipe with a neat external appearance. Straight seam pipe shall have not more than two longitudinal butt welded seams. Girth seams shall be butt welded and shall not be closer than 6 feet apart except in specials and fittings. Spiral lap welded steel pipe is not allowed. Pipe shall be provided in lengths of approximately 20 feet.

C. Steel pipe wall thickness shall be as specified in the applicable Standards or as determined by the supplier to meet the performance and pressure ratings specified herein in accordance with the provisions of AWWA Manual M11.

D. Circumferential deflection of all pipe in-place shall not exceed 2.0 percent of the pipe diameter.

E. Tapped bosses for connection of small diameter pipes to main lines shall be welded-on Steel "Weld-O-Let" with tapped outlet and contoured mating surface to the pipe wall. Tapped bosses shall be shop fabricated with the pipe, and all coatings and linings of the pipe shall be repaired at the location of installation of the tapped boss.

2.02 STEEL PIPE FITTINGS

A. Fittings shall be manufactured to standard dimensions, suitable for the pressures specified. Fittings shall be provided of the same or heavier wall thickness and/or pressure rating as the pipe of which they are a part. Strength, physical and chemical requirements shall meet or exceed the requirements specified for the pipe.

B. Fittings for pipe 2 inches diameter and less shall be of the screwed pattern, except as shown or specified otherwise.

1. Screwed fittings 2 inches and smaller shall be malleable iron flat bank fittings, ASME B16.3, 125 pounds. For high pressure service, conform to ASME B16.3, 250 pounds. Malleable iron shall conform to the requirements of ASTM A197.

2. Where shown or specified, screwed end fitting of cast iron, conforming to the requirements of ASME B16.4, 125 pound standards for general service and 250 pound for high pressure service shall be provided. Cast iron shall meet the requirements of ASTM A126.

3. All threads shall be clean cut and smooth conforming to the American Standard for Pipe Threads, ASME B1.1.

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4. Unions shall be of malleable iron fitted with brass to iron seats.

5. For galvanized pipe, fittings shall also be hot dipped galvanized and shall conform to ASTM A153.

C. Socket Welding Fittings

1. Socket welding fittings shall be provided on pipe three inches and smaller, and shall meet the requirements of ASME B16.11 with steel conforming to ASTM A105/A105M, Grade 2. Fittings shall be rated 2000 pounds minimum.

2. Socket welding fittings shall be welded in conformance with the applicable provisions of the Code for Pressure Piping, ASME B31.1.

D. Butt Welding Fittings

1. Butt welding fittings shall be provided on pipe greater than three inches diameter, and shall meet the requirements of ASME B16.9.

2. Where welding fittings are approved for assembly in cement lined pipelines, fittings shall be provided with a plain end, grooved end or shouldered end section welded on each end of the fitting and assembled with sleeve-type, groove type, or shoulder-end couplings as required. Long tangent welding fittings may be substituted for welded-on spool piece fittings provided that they can accommodate the flexible pipe couplings.

E. Flanged Fittings

1. Provide cast iron or steel flanged fittings where shown on the Drawings or specified herein.

2. Cast iron flanged fittings for general service shall conform to the requirements of ASME B16.1.

3. Steel flanged fittings shall utilize forged steel slip-on flanges. Fittings shall be Class 125 and Class 250 fittings conforming to the requirements of ASME B16.5, 150 pound or 300 pound, respectively as specified, except flanges that are plain faced shall be provided. Provide Class 125 fittings conforming to AWWA C207, Class B.

4. Cast steel flanged fittings shall be assembled with forged steel flanges of the same pressure rating, conforming to the requirements of ASME B16.5.

F. Fabricated Steel Fittings

1. Unless otherwise shown or specified, fittings 24 inches and larger shall be fabricated in accordance with the Code for Pressure Piping, ASME B31.1 and as specified herein.

2. The minimum radii of the centerlines of bends shall be 1.5 times the nominal pipe diameter unless specifically shown otherwise on the Drawings. The included angle between the point of tangency of the bend and connecting straight pipe shall include not less than the number of bend segments as follows:

Bend	Number of Full Segments	Number of Part Segments

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75 – 90 deg.	4	2
60 – 74 deg.	3	2
45 – 59 deg.	2	2
30 – 44 deg.	1	2
0 – 29 deg.	0	2

Full segments shall consist of sections with ends cut to form included angles of 15 degrees; part segments shall consist of section up to 7-1/2 degrees. In accordance with the above table, a 90 degree bend shall require four 15 degree segments, two 7-1/2 degree segments at the ends of the fitting and one additional 15 degree segment.

3. Fittings for cement line pipelines shall be lined after fabrication.

4. Fabricated fittings intended for installation with flexible pipe couplings shall be provided with extra long end segments extending past the point of tangency of the radius to the segment centerline to accommodate the length of the coupling and any required joint restraint.

5. Reducers shall be provided with the same laying length as American Standard Class 125.

6. Fabricated fittings shall be reinforced in accordance with AWWA Manual M11.

2.03 JOINTS FOR STEEL PIPING

A. Joints for steel piping two inches diameter and less shall be screwed joints with clean cut threads conforming to the American Standard for Pipe Threads, ASME B1.1. Screwed joints shall be made up with good quality thread compound, suitable for the intended service, applied to the make thread only.

B. Joints for steel piping larger than two inches shall be welded with butt, socket, or slip-on welded flanges.

C. Flanged joints for steel pipe shall be of the slip-on welding type with hubs meeting the requirements of ASME B16.5, or butt welded welding neck flanges meeting the requirements of ASME B16.5. Flanged joints for steel water pipe shall conform to AWWA C207. Slip-on flanges shall be welded to the steel pipe at the hub and at the pipe end in conformance with the Code for Pressure Piping, ASME B31.1. Flanges shall be plain flat faced for connections to cast iron valves, fittings, and equipment. Raised face flanges shall be provided to connections to adjacent steel pipe and fittings.

1. Blind flanges shall be in accordance with ASME B16.5 plain faced.

2. Where flanged connections are indicated or otherwise required on pipe 2-in or less for connection to flanged valves, fittings and appurtenances, they shall be made up using companion type flanges. Where flanged fittings are indicated or otherwise required, they shall be made up using threaded steel nipples and steel companion type flanges. Companion flanges shall be steel, 150 lb ANSI Standard flat face flanges of the threaded type. Flanges shall be spot faced on the back around each bolt hole. For galvanized pipe, flanges shall also be hot-dipped galvanized.

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3. Steel 150 pound welding flanges shall be used for assembly with Class 125 cast iron flanged fittings, valves, and equipment. Steel 300 pound flanges shall be used for assembly with Class 250 cast iron flanged fittings, valves, and equipment. AWWA Class B steel hub flanges shall be used for assembly with 25 pound cast iron flanged fittings.

4. Flanged joints shall be made with bolts or bolt studs with a nut on each end. Stud bolts shall be used for all bolting sizes 1-3/4 inches and larger. Bolts, stud bolts, and nuts shall meet the requirements of ASTM A307 Grade B, except for high temperature service where alloy steel bolts, ASTM A193/A193M, Grade B5 shall be used. Bolts and stud bolts shall conform to the dimensional requirements of ASME B18.2.1 with rolled threads conforming to ASME B1.1, Coarse Series, Class 2 fit. Bolts and stud bolts and nuts shall be of American Standard heavy unfinished hexagonal type. Bolts shall be provided with a 1/4-inch projection beyond the nut when the joint with gasket is assembled.

5. Flange gaskets shall be ring type gaskets for pipe larger than 12 inches diameter, and full face gaskets for pipe sizes 12 inches diameter and smaller. Gasket dimensions shall conform to the requirements of ASME B16.21, unless specified otherwise. Gaskets shall be as thin as the finish and accuracy of the flange surface will permit.
   a. For general service, rubber gaskets shall be 1/8 inch thick and meet the requirements of AWWA C207.
   b. Gasket material shall be specifically recommended for the service by the gasket manufacturer and as approved by the Engineer.

6. Insulated flanged joints shall be provided as indicated on the Drawings. Flange insulation kits shall include flange insulating gasket, flange bolt insulating sleeves, and bolt insulating washers.

2.04 INTERIOR LINING

A. Linings shall be applied in accordance with AWWA Standards. Linings for pipe shall be factory applied except for cut-backs as required for field welded pipe. Field welding of pipe shall be permitted only for pipe assemblies that can be field repaired and field re-coated following welding. Utilize flanged joints wherever linings cannot be accessed to perform thorough repair and recoating for welded pipelines.

1. Where specified herein, the interior of the pipe shall be coated with an NSF 61-approved epoxy lining, in accordance with AWWA C210. The lining shall be applied in two coats achieving a minimum dry film thickness of 16 mils. The epoxy-lining shall be Tnemec Series 22; FC-22 or equal.

2. Where specified herein, the interior of the pipe shall be cement mortar lined in accordance with AWWA C205, shop applied. Field repair of cement mortar lining after field cutting or welding shall be in accordance with AWWA C602. Fabricated pipe and fittings shall be cement mortar lined after fabrication. Apply a seal coat of asphaltic material in conformance with AWWA C203 over the cement mortar lining. Seal coat for potable water piping shall be NSF 61 approved.

2.05 SURFACE PREPARATION AND SHOP PRIME PAINTING

A. All piping and fittings exposed to view shall have its surface prepared and be shop primed as specified in Section 09901. Surface preparation and shop priming is a part of the work of this

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Section. Pipe finish painting and marking is included in Division 9, but it shall be part of the work of this Section to assist as required by the Engineer in identifying pipe contents, direction of flow and all else required for proper marking of pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. Steel pipe shall be installed true to alignment, and rigidly supported anchors shall be provided where required under Section 15140 or as shown on the Drawings. Where temporary supports are used during construction, provide sufficient strength and rigidity to prevent shifting or distortion of the pipe. After installation, the piping shall be tested as specified herein.

B. When cutting of pipe is required, the cutting shall be done by machine in a neat workmanlike manner without damage to the pipe. Cut ends shall be smooth and at right angle to the axis of the pipe. All steel pipe shall be thoroughly cleaned before installation including smoothing and cleaning interior and exterior cut ends. All uncoated pipes shall be placed on end and hammered to remove scale and loose particles. Any damage to linings shall be repaired to the satisfaction of the Engineer before the pipe is installed.

C. Welding of steel butt-welding fittings, steel fabricated fitting and steel pipe shall be in strict conformity with the Code for Pressure Piping, ASME B31.1, Section 6 and its Supplements. Certificates of qualifications of current issue, conforming to the requirements of the Code shall be submitted to the Engineer before proceeding with any pipe welding. Backing rings shall be used for all pipe welding butt joints unless otherwise specified. Backing rings shall be of carbon steel with spacer nubs that strike-off or melt with the weld.

D. Field welding of cement mortar lined steel pipe shall be performed only where approved and in accordance with AWWA C206. Joints not approved for field welding shall be flanged or couplings as specified.

1. The ends of the lined pipe for pipe-to-pipe joints shall be machine cut to provide an approximate bevel of 27-1/2 degrees. Ends may be chipped provided there is no damage to the cement lining. Ends shall be cleaned of scale, rust, oil and other foreign matter. Where fittings already having a bevel of 37-1/2 degrees are to be welded to pipe, pipe ends shall be beveled to a 17-1/2 degree angle, making a total angle of bevel between joints of approximately 55 degrees. A 1/8 inch land shall be provided where possible.

2. Pipe ends to be joined shall be approximately 1/32 inch apart before tacking. Backing rings shall not be used at welded joints in cement mortar lined pipe. Small tack welds shall be made using a 1/8 inch electrode. The first bead or layer of welding shall be laid by bridging across from bevel to bevel at the bottom of the groove just at the top of the land. A suitable crown reinforcement layer shall be made on the top of the joint to finish off.

3. Direct current (DC) shall be used for welding, with the base material on the negative side.

4. The first pass shall be a stringer bead using a 1/8 inch electrode with a current of 80 to 90 amperes at 50 to 55 Volts. The second and succeeding passes shall be woven beads using a 1/8 inch electrode and a current of 90 to 100 amperes at 55 to 58 Volts. All passes shall be made slowly and with care not to burn through the land or the shoulder into the lining of

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the pipe. The joint shall not be hotter than 100 deg. F. For large size pipe, a 5/32 inch electrode may be used, provided the temperature of the joint is held within 100 deg. F.

5. No stress relieving of welded joints is necessary unless the pipe wall thickness warrants it. After the weld is completed, the joints in the lining shall be filled with a special compound of a wet slurry mix of the same cement used for the lining. Where accessible from the end of the pipe, the welded joint shall be swabbed with cement using a paint brush thoroughly wetted with the cement slurry.

6. Any defects causing leaks in welded joints shall be repaired by welding without damaging the cement lining using procedures similar to that specified hereinbefore.

7. Finished welds shall be examined as required by AWWA C206.

E. All threads shall be clean machine cut to the dimensions of the American Standard for Pipe Threads, ASME B1.1. All burrs, dirt and foreign matter shall be removed. Screwed joints shall be made up with good quality thread compound applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned and new compound applied. All joints shall be air tight. For potable water lines, an NSF61 approved pipe compound shall be used.

F. Bolts in flanged joints or mechanical joints shall be tightened alternately and evenly. Bolt holes of flanged joints shall straddle the horizontal and vertical centerline of the pipe. Clean flanges by wire brushing before installing flanged connections.

G. All piping shall have a sufficient number of unions, flanged joints, or coupling joints that can be dismantled to allow convenient removal of piping. Unions shall be compatible with pipe.

H. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe by the Contractor, at the Contractor's own expense.

3.02 TESTING

A. All pipelines shall be tested in accordance with Section 01445.

B. If leaks are discovered, they shall be repaired under this Section and approved by the Engineer.

C. If any joint or pipe section proves to be defective, it shall be repaired to the satisfaction of the Engineer.

3.03 DISINFECTION

A. All pipelines that are to carry potable or protected water shall be disinfected in accordance with Section 01445.

3.04 FIELD PAINTING

A. Pipes shall be field painted and marked in accordance with Section 09902.

END OF SECTION

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SECTION 15063
COPPER PIPE AND TUBING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the basic materials and methods of installation for non-buried copper pipe and tubing. Specific uses and applications are specified in other Sections and on the Drawings.

1.02 RELATED WORK

A. Pipeline testing, cleaning and disinfection are included in Section 01445.

B. Buried piping and appurtenances are included in Division 2.

C. System applications for copper pipe and tubing are specified in other Sections of Division(s) 11, 13, and 15.

D. Piping – General Requirements is included in Section 15051.

E. Valves and appurtenances are included in Section 15100.

F. Piping specialties are included in Section 15120.

G. Pipe hangers and supports are included in Section 15140.

H. Pipe insulation is included in Section 15250.

I. Electric heat tracing is included in Section 15257.

J. Piping pertaining to Plumbing and HVAC is included in Sections 15400 and 15500, respectively.

1.03 SUBMITTALS

A. Refer to Section 15051 and specific System Sections for submittal requirements.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM B32 - Standard Specification for Solder Metal

2. ASTM B42 - Standard Specification for Seamless Copper Pipe, Standard Sizes

3. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings

4. ASTM B75 - Standard Specification for Seamless Copper Tube

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

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6. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

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

B. American Society of Mechanical Engineers (ASME)

1. ASME B16.15 - Cast Bronze Threaded Fittings Classes 125 and 250

2. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings

3. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

4. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings (DWV)

5. ASME B16.24 - Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 900, 1500 and 2500.

6. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes

7. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings (DWV)

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

PART 2 PRODUCTS

2.01 PIPE AND TUBING

A. Copper pipe, Cu1, shall conform to ASTM B88, Type K.

B. Copper pipe, Cu2, shall conform to ASTM B88, Type L.

C. Copper pipe, Cu3, shall conform to ASTM B306, DWV, Temper H.

D. Copper pipe, Cu4, shall conform to ASTM B42, Temper H80, drawn.

E. Copper pipe, Cu5, shall conform to ASTM B75, Type C12200 (DHP), seamless, deoxidized.

F. Copper pipe, Cu6, shall conform to ASTM B280, deoxidized and dehydrated.

2.02 FITTINGS

A. Type CF-1, cast bronze, threaded adaptors, 150 lb, screwed, ASTM B62, ANSI/ASME B16.15.

B. Type CF-2, brass tube solder type, ASTM B62, ASME B16.18.

C. Type CF-3, wrought copper, solder type, ASTM B75, ASME B16.22.

D. Type CF-4, cast brass or bronze recessed drainage pattern, ASME B16.23.

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E. Type CF-5, flange fittings, 150 lb, ASME B16.24.

F. Type CF-6, 125 lb, flared or compression type copper unions, ASME B16.26.

G. Type CF-7, soldered cast brass or wrought copper drainage pattern, ASME B16.29.

H. Type CF-8, 125 lb, bronze unions with ground joint seats, ASTM B62.

I. Type CF-9, flareless unions, Parker "Intru-Lok", Crawford "Swagelok" or equal.

2.03 JOINT MATERIALS

A. Type S-1, Solder Alloy TC (95 percent Tin, 4.85 percent Copper 0.15 percent Selenium), ASTM B32, lead free, certified to comply with ANSI/NSF 61. No solder containing lead shall be utilized on the project.

B. Type S-2, brazing filler metal classified as BCu4 or BCu5, with minimum melting point of 1300 degrees F. Use wrought fittings for brazing.

PART 3 EXECUTION

3.01 JOINING OF PIPE

A. 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. 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.

B. Screwed Connections

1. All screwed connections shall have full thread of true taper, accurate to gauge, and conform to ANSI B2.

2. Reduction in size shall be made using reducing fittings.

3. The use of bushings or close nipples is prohibited.

4. Plugs shall be steel or brass with square head.

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5. Screwed joints shall be made with an approved joint compound applied to the male thread only. Caulking of screwed joints will not be allowed.

C. Soldering (Copper Tubing)

1. Tubing shall be cut with square ends and reamed to prevent burrs, out-of-round or improperly sized ends.

2. After cutting, all surfaces to be soldered shall be thoroughly cleaned to a metal-bright finish, free from dirt, grease or other material before fluxing and soldering. This cleaning shall be performed by using emery cloth, sandpaper or steel wool. Clean the outside end of the tubing for a length of 1/2-in greater than the depth of the fitting. The inside of the fittings shall be cleaned in a similar manner. Apply non-corrosive flux and assemble the joint. Acid solder or acid flux will not be allowed.

3. The surfaces to be joined shall be heated up slowly and uniformly to the melting point of the solder. The surface being soldered shall be maintained above the melting point of the solder for sufficient time to draw the solder completely into the joint. When the solder congeals to a plastic state the excess metal shall be removed with a cloth brush, leaving a fillet around the end of the fitting. Full penetration of the solder uniformly throughout the entire socket is required. The soldered joints shall be allowed to cool in still air. Quenching will not be permitted.

4. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Peening for closing up defects will not be permitted.

5. Heating torches of sufficient size equipped with multiple tips or ring burners for use on combination torches, shall be used for heating of large fittings of 2-in diameter and larger prior to soldering.

6. Remove all external and internal loose solder and flux after joint cools.

D. Brazing

1. Cutting and cleaning of tubing shall be as specified for soldering operations.

2. Apply flux in accordance with recommendations of manufacturer of brazing filler material being used. Apply to outside of fitting and heat affected area of tubing. Avoid getting flux inside tube. Flux may be omitted when joining copper tubes to wrought copper fittings but is required for joining to cast (bronze) fittings.

3. Assemble joint by inserting tube into socket hard against stop and turning.

4. Heat parts to be joined beginning 1-in from edge of fitting, continuously moving the flame. When flux has become transparent, begin to heat the fitting at the base of the cup, still continuously moving the flame. When flux at fitting is quiet and transparent, maintain heat along joint by moving flame along axis between fitting and tubing.

5. Apply brazing material at point were tubing enters socket of fitting. Avoid putting flame on brazing material. Heated joint should melt brazing material and capillary action will draw

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material into the joint. When joint is properly made, a fillet of filler metal will be visible completely around the joint. Stop adding filler metal when fillet is formed.

6. After brazing material has solidified, clean off flux residue. Fittings must cool naturally. Quenching will not be allowed.

7. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Penning for closing up defects will not be permitted.

E. Flared (Copper)

1. Soft copper (annealed) tubing and flare type fittings are required for this joint.

2. The tube must be cut square and reamed and burred in preparation.

3. Slip the sleeve-nut of the fitting over the tube end with the threaded end of the nut facing the end of the tube.

4. Lubricate the flaring tool with a drop of oil and center it carefully inside the tube. Drive the flaring tool with a hammer, keeping it plumb, until the tube has flared to the outside diameter of the tool.

5. After removing the flaring tool by pulling and twisting, clean flared surfaces of the tube and fitting, insert male end of fitting into sleeve and draw threaded sleeve-nut up tight with wrenches.

6. Leaks may be corrected by recleaning the flared surfaces and retightening.

7. Cracked or split flared surfaces of the tubing shall be cut off and the tubing reflared.

8. Peening or packing a leaking joint will not be permitted.

3.02 TESTING

A. All pipelines shall be tested in accordance with Section 01445.

B. If leaks are discovered, they shall be repaired under this Section and approved by the Engineer.

C. If any joint or pipe section proves to be defective, it shall be repaired to the satisfaction of the Engineer.

3.03 DISINFECTION

A. All pipelines that are to carry potable or protected water shall be disinfected in accordance with Section 01445.

END OF SECTION

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APPENDIX A

COPPER PIPE AND TUBE
GUIDANCE SHEET

ASTM B88, Type K (Cu1)

Greatest wall thickness; available in drawn tempers H58 and H80 and annealed tempers 050 and 060; suitable for water distribution (H80), condensate drain (H80), oxygen systems (cleaned to recommendation of NFPA publication No. 56F, Nonflammable Medical Gas Systems). Use with fittings CF-1, CF-2, CF-3, CF-5, CF-6, CF-8 and CF-9.

ASTM B88, Type L (Cu2)

Available in drawn tempers H58 and H80 and annealed tempers 050 and 060; suitable for plumbing drain 2-in and smaller (H80), water systems (H80), equipment drains and vents (H80), high pressure air (H80), hot water heating system (050), oxygen systems (cleaned to recommendations of NFPA publication No. 56F, Nonflammable Medical Gas Systems), seal water system (H80), air conditioning and refrigeration (060 coils) (H80 straight lengths). Specify tubing for refrigeration to be factory cleaned, dried and charged with dry nitrogen and sealed with pressure tight caps. Use with fittings CF-1, CF-2, CF-3, CF-5, CF-6, CF-89 and CF-9.

ASTM B306, Type DWV (Cu3)

Available in drawn temper only; suitable for plumbing drain, waste and vent system over 2-in. Use with fittings CF-4 and CF-7.

ASTM B42, (Cu4)

Copper pipe. Use when pipe threading is required. Heavy wall thickness. Available in tempers 061, annealed; H80 drawn (1/8-2-in); H55 light drawn (2-12-in).

ASTM B75, Type C12200 (Cu5)

Available in tempers H58 and H80 (drawn) and 050 and 060 (annealed). Suitable for instrument air and compressed air. Use with fittings specified for Cu1 and Cu2.

ASTM B280 (Cu6)

Available in tempers H58 (drawn) and 060 (annealed coils). For use with gas and refrigeration piping "in the field for connections, repairs and alterations". Use with fittings specified for Cu1 and Cu2.

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SECTION 15064
PLASTIC PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install 1/8-in to 6-in, non-buried plastic piping and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Wall sleeves are included in Section 01172.

B. Pipeline testing, cleaning and disinfection are included in Section 01445.

C. Buried piping and appurtenances are included under Division 2.

D. Concrete work is included in Division 3.

E. Field painting is included in Section 09902.

F. Piping – General Requirements is included in Section 15051.

G. Valves and appurtenances are included in Section 15100.

H. Piping specialties are included in Section 15120.

I. Pipe hangers and supports are included in Section 15140.

J. Thermal insulation is included in Section 15250.

K. Electric heat tracing is included in Section 15257.

1.03 SUBMITTALS

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

1. Shop drawings including piping layouts and schedules shall be submitted to the Engineer and shall include dimensioning, fittings, locations of valves and appurtenances, joint details, methods and locations of supports and all other pertinent technical specifications for all piping to be furnished.

2. Shop drawing submittals for piping under this Section shall include all data and information required for the complete piping systems. All dimensions shall be based on the actual equipment to be furnished. Types and locations of pipe hangers and/or supports shall be shown on the piping layout for each piping submittal.

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1.04 REFERENCE STANDARDS

A. ASTM International.

1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

2. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.

3. ASTM D2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.

4. ASTM D2464 - Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

5. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

6. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

7. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

8. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.

9. ASTM D2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings.

10. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

11. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

12. ASTM D3311 - Standard Specification for Drain, Waste and Vent (DWV) Plastic Fittings Patterns.

13. ASTM F437 - Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

14. ASTM F438 - Standard Specification for Socket - Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.

15. ASTM F439 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

16. ASTM F441 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.

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17. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

18. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.

19. ASTM F594 - Standard Specification for Stainless Steel Nuts.

B. Plastics Pipe Institute (PPI)

1. PPI TR31 - Underground Installation of Polyolefin Piping.

C. American National Standard Institute (ANSI)

1. ANSI B16.5 Pipe Flanges and Flanged Fittings.

D. National Sanitation Foundation (NSF)

1. NSF/ANSI 14 – Plastics Piping System Components and Related Materials.

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. All plastic pipe and fittings of each type shall be furnished by a single manufacturer who is experienced in the manufacture of the items to be furnished; however, it shall not be a requirement that the pipe and fittings be manufactured by the same manufacturer, provided that the pipe and fittings are compatible in both compounding and size. The pipe and fittings shall be designed, constructed and installed in accordance with the best practices and methods and shall be suitable for the intended service.

1.06 SYSTEM DESCRIPTION

A. Piping shall be installed in those locations as shown on the Drawings.

B. The equipment and materials specified herein are intended to be standard types of plastic pipe and fittings for use in transporting wastewater, water, air and chemicals.

C. Plastic piping systems shall be designed for the following conditions:

1. System: Aluminum Sulfate (Alum)
   a. Material: Schedule 80 PVC
   b. Fluid: Aluminum Sulfate, 48%
   c. Pressure: Atmosphere to 100 psig
   d. Flow Velocity: Up to 10 fps
   e. Temperature: 35 to 100 degrees F
   f. Special Conditions: Pulsation from diaphragm pumps

2. System: Dewatering Polymers
   a. Material: Schedule 80 PVC
   b. Fluid: Concentrated (neat) emulsion polymer and polymer solution

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c. Pressure: Atmosphere to 100 psig
d. Flow Velocity: Up to 10 fps
e. Temperature: Ambient
f. Special Conditions: Viscosity up to 30,000 cP

3. System: Odor Control Systems
   a. Material: Schedule 80 PVC
   b. Fluid: Drainage from packaged odor control systems
   c. Pressure: Atmosphere to 100 psig
   d. Flow Velocity: Up to 10 fps
   e. Temperature: Ambient
   f. Special Conditions:

4. System: Potable & Non-Potable Water
   a. Material: Schedule 80 PVC
   b. Fluid: Potable or non-potable water
   c. Pressure: Atmosphere to 150 psig
   d. Flow Velocity: Up to 10 fps
   e. Temperature: Ambient
   f. Special Conditions:

PART 2 PRODUCTS

2.01 MATERIALS

A. Poly (Vinyl Chloride) Pipe and Fittings - PVC

1. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454-B in accordance with ASTM D1785, PVC 1120. The pipe shall have a minimum hydrostatic design stress of 2,000 psi at 73 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise shown.

2. Fittings shall be the socket type for solvent welded joints conforming to ASTM D2467 or ASTM D2466 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from PVC compound meeting ASTM D1784, Class 12454-B. Solvent cement shall be as specified in ASTM D2564.

3. Pipe, fittings and solvent for use with potable water shall be certified by NSF in accordance with NSF/ANSI Standard No. 14. All such products shall be legibly and permanently marked in accordance with NSF/ANSI 14.

B. Poly (Vinyl Chloride) Pipe and Fittings for Drain, Waste and Vent Service (DWV).

1. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454-B in accordance with ASTM D2665. The patterns, dimensions and laying lengths of fittings including adapters shall meet the requirements of ASTM D3311. Solvent cement for joining DWA pipe and fittings shall be as specified in ASTM D2564.

C. Chlorinated Poly (Vinyl Chloride) Pipe and fittings - CPVC

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1. Pipe shall be manufactured from CPVC compounds meeting ASTM D1784, Class 23447 in accordance with ASTM F441, CPVC 4120. The pipe shall have a minimum hydrostatic design stress of 2000 psi at 73 degrees F and 500 psi at 180 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise shown.

2. Fittings shall be socket type for solvent weld joints conforming to ASTM F439 or ASTM F438 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from CPVC compound meeting ASTM D1784, Class 23447. Solvent cement shall be as specified in ASTM F493.

D. Polyethylene Pipe and Fittings - HDPE

1. Pipe shall be manufactured from High Density Polyethylene (HDPE) base resin conforming to Grade P34 (PPI PE3406 or better) in accordance with the requirements of ASTM D2447. The pipe shall have a minimum hydrostatic design stress of 630 psi at 73 degrees F and be suitable for field cutting and heat fusion joining. Pipe shall be of the sizes shown on the Drawings and shall be Schedule 80 unless otherwise shown.

2. Fittings shall be the butt type for heat fusion joints conforming to ASTM D3261, except that Schedule 80 fittings shall meet the sustained pressure test conditions as specified for Schedule 80 pipe in Table 3 of ASTM D2447. Fittings shall be manufactured from the same HDPE base resin, conforming to Grade P34, Class C (PPI PE3406 or better), as is used to produce the pipe to which the fittings are to be joined. Both pipe and fittings shall be manufactured by the same manufacturer to assure compatibility of the piping system components.

E. Threaded joints shall be as specified under the applicable ASTM standard for the pipe and fittings being used. Thread sealer shall be thread tape which shall be standard industrial quality Teflon, Type 1.

F. Flanged Joints

1. Where flanged joints are shown on the Drawings, they shall be supplied with 1/8-in thick full-faced gaskets made of a material compatible with the fluid service.

2. Flange bolt spacing, number and dimensions shall conform to the requirements of ANSI B16.5. CPVC and PVC flanges shall be suitable for solvent cementing to the pipe and shall be suitable for a minimum pressure of 150 psi.

3. Bolts, nuts and washers for flanged joints shall be for corrosive service conditions and shall be ASTM F593 and F594, Type 316 stainless steel. Anti-seize compound for stainless steel bolts and nuts shall be of a molybdenum disulfide base such as Molycoat-G or equal.

G. Fittings, specials, unions and flanges shall be of the same schedule number and manufactured of the same materials as the pipe. Whenever unions are called out on the Drawings, flanged connections may be substituted, provided that dimensional controls do not preclude use of flanges.

H. Sleeves for plastic pipe shall be as specified in Section 01172.

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I. Expansion joints for PVC and CPVC sizes 1/2-in to 6-in shall be telescoping type as manufactured by Plastinetics, Inc.; ASAHI/America or equal. Expansion in pipes smaller than 1/2-in shall be accommodated with expansion loops.

PART 3 EXECUTION

3.01 INSTALLATION

A. The installation of plastic pipe shall be strictly in accordance with the manufacturer's technical data and printed instructions.

B. Joints for PVC and CPVC pipe shall be solvent cemented unless flanged or threaded are otherwise shown on the Drawings or are specified as other types herein. In making solvent cemented connections, clean dirt and moisture from pipe and fittings, bevel pipe ends slightly with emery cloth to remove any shoulder or burrs created by cutting of the pipe. Solvent cement joints shall be made in accordance with ASTM D2855 except that solvent cement formulated especially for and as specified above shall be used for joining CPVC pipe and fittings. Primer shall be used whenever recommended by the pipe, fitting, or cement manufacturer and in all cases for joints on pipe systems 4-in in diameter or larger. Making solvent cement joints shall not be performed and the work shall stop when the temperature, measured in the shade, is 40 degrees F and falling.

C. Joints between PVC drain, waste and vent pipe and cast-iron soil pipe shall be made with approved mechanical compression joints designed for such use.

D. Joints for HDPE pipe shall be butt heat fusion. Butt heat fusion joints shall be made in accordance with the requirements of ASTM D2657.

E. Installation of valves and fittings shall be in accordance with manufacturer's instructions. Particular care shall be taken not to overstress threaded connections. In making solvent cement connections, the solvent cement or primer shall not be spilled on valves. Any cement allowed to run from joints shall be cleaned from the pipe and fittings immediately.

F. All piping shall have a sufficient number of unions to allow convenient removal of piping and shall be as approved by the Engineer. PVC and CPVC pipe shall be installed with at least one expansion joint or loop near the center of each straight run of pipe which is 50-ft or longer with the maximum spacing between expansion joints or loops being 150-ft.

G. Where plastic pipe passes through wall sleeves, the space between the pipe and sleeve shall be sealed with a mechanical sealing element as specified in Section 01172.

H. All plastic pipe to metal pipe connections shall be made using flanged connections. Metal piping shall not be threaded into plastic fittings, valves, or couplings nor shall plastic piping be threaded into metal valves, fittings or couplings. Only socket to thread adaptors shall be used for threaded plastic pipe connections to other threaded devices.

I. Concrete inserts for hangers and supports shall be furnished and installed in the concrete as it is placed. The inserts shall be set in accordance with the requirements of the piping layout and the Contractor shall verify these locations from approved piping layout drawings and the structural drawings. Pipe hangers and supports are specified in Section 15140.

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J. Due to its large coefficient of thermal expansion, HDPE pipe shall be installed at its maximum operating temperature to prevent sagging between the hangers or supports. Supports at each end of the straight HDPE pipe runs shall be of sufficient strength to develop anchoring forces adequate to oppose the tensile forces developed in the pipe due to thermal contraction. The exception to this requirement shall be for flanged HDPE connections, because, if the flanged connection is made up at the maximum operating temperature, the thermal contraction of the flange thickness will reduce the required tensile force in the flange bolts. Flanged HDPE connections shall, therefore be made up at the lowest expected operating temperature and then the entire piping system shall be brought up to the maximum operating temperature for final installation. (Note: Packing the flanges in ice may be necessary to achieve the proper installation temperature).

3.02 FIELD TESTING

A. All pipelines shall remain undisturbed for the minimum curing or cooling time specified for each type of pipe material but no less than 8 hours to develop full curing and complete strength at all joints.

B. All pipe systems shall be flushed clean and then subjected to a hydrostatic pressure test for 12 hours at the test pressures and temperatures specified in Section 01445. Testing procedures shall be as specified below and in Section 01445. Should the temperature not be attainable under hydrostatic conditions, then the test may be performed under hydro-dynamic conditions, provided that accurate measurements for loss of the test fluid can be made, or the pressure shall be proportionally increased to simulate the stresses of the higher temperature in relation to the lowest system temperature that is expected during the duration of the test. The proportionally higher test pressures shall be determined in accordance with the accepted temperature versus strength properties as published by the pipe manufacturer, PPI or other pipe material standards organization. Allowance for expansion of polyethylene pipe during the test shall be made in accordance with PPI Technical Report TR31.

C. The test shall be performed by slowly filling the piping system, expelling entrapped air from all high points. The fill rate shall be controlled so that the fluid velocity within the pipe system is less than 2 fps. Upon completion of the filling process, the system shall be brought up to the specified test temperature as applicable, holding the system pressure to less than 10 percent of the test pressure. Once the system has been stabilized at the specified test temperature, the pipe should be slowly brought up to the test pressure in such a manner so as to not create shock, surge or water hammer in the pipe system. The test duration time limit shall not begin until the full pressure specified above has been reached and the system has been stabilized to within 5 percent of the test temperature. The system pressure and temperature shall be maintained to within 1/2 percent but no more than 5 percent of the specified value for the temperature and within 5 psi of the specified value for the pressure. These tolerances shall be held for the entire duration of the test. Upon completion of the test, the pressure shall be slowly removed by opening a valve or other pressure relieving device at a location remote to the location of the pressure/temperature monitoring equipment.

D. The pressure test shall be monitored by a recording type pressure gauge for tests not requiring temperature control or a dual pen pressure/temperature recording gauge when temperature control is required. The entire test process shall be recorded, including the initial temperature stabilization and pressurization of the piping system. The record shall be continuous through the system test and shall show the final de-pressurization of the pipe system.

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E. All visible leaks detected during the pressure test shall be repaired and the pressure/ temperature test rerun. A successful test shall be a test in which no visible leaks are detected and the pipe system pressure can be maintained within 1/2 percent but no more than 5 psi of the specified value.

F. Prior to testing, the pipelines shall be supported in an approved manner to prevent movement during the tests.

3.03 DISINFECTION

A. All pipelines that are to carry potable or protected water shall be disinfected in accordance with Section 01445.

3.04 PAINTING

A. All CPVC and PVC pipe and fittings exposed to the direct sunlight shall be field painted to provide additional UV protection. This painting shall be required whether or not marking is required and shall be in accordance with Section 09902.

END OF SECTION

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SECTION 15066
STAINLESS STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install, test, complete and ready for operation all stainless steel pipe as shown on the Drawings and as specified herein.

B. Where the word "pipe" is used it shall refer to pipe, fittings, hangers, supports and appurtenances unless otherwise noted.

C. The work includes, but is not necessarily limited to:

1. Furnishing and installing interior, above grade, stainless steel pipe, fittings and specials with screwed, butt welded, or flanged and plain ends.

1.02 RELATED WORK

A. Testing is included in Section 01445.

B. Field painting is included in Section 09902.

C. Instrumentation and controls, other than those specified herein, are specified under their respective Sections of Division 13.

D. Valves and appurtenances are included in Section 15100.

E. Piping specialties are included in Section 15120.

F. Pipe hangers and supports are included in Section 15140.

G. Thermal insulation is included in Section 15250.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, the following:

1. Within 30 calendar days following effective date of the Agreement submit the name of the pipe, fitting and appurtenances manufacturers and a list of the material to be furnished by each manufacturer.

2. Shop drawings including piping layouts and schedules, including dimensioning, fittings, expansion joints, locations of valves and appurtenances, joint details, wall penetration details, methods and locations of supports and all other pertinent technical specifications for all piping to be furnished. Shop drawings shall include all data and information required for the complete piping systems. All dimensions shall be based on the actual equipment to be furnished. Types and locations of pipe hangers and/or supports shall be shown on the piping layouts for each pipe submittal. Not all dimensions will be checked by

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the Engineer, nor will detailed review be performed. Contractor shall be responsible for accurate dimensioning of piping systems.

3. Proposed cleaning method, including precleaning, descaling, chemicals to be used, or mechanical descaling method and final cleaning/passivation

4. Certifications that welders are qualified, in accordance with ANSI B31.1, Paragraph 127.5 for shop and project site welding of pipe work.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A312 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.

2. ASTM A530 - Standard Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.

3. ASTM A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.

B. American National Standards Institute (ANSI)

1. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125 and 250.

2. ANSI B16.9 - Factory-Made Wrought Steel Buttwelding Fittings.

3. ANSI B36.19 - Stainless Steel Pipe

C. American Water Works Association (AWWA)

1. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

D. American Society of Mechanical Engineers (ASME)

1. ASME B31.1 - Power Piping.

E. American Welding Society (AWS)

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. Stainless steel pipe and fittings shall be furnished by a single manufacturer who is fully experienced, reputable, qualified and regularly engaged for the last 5 years in the manufacture of the materials to be furnished. The pipe and fittings shall be designed, constructed and installed in accordance with the best practices and methods and shall comply with this Section.

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1.06 SYSTEM DESCRIPTION

A. Piping shall be installed in those locations as shown on the Drawings.

B. The equipment and materials specified herein are intended to be standard types of stainless steel pipe and fittings for use in transporting waste activated sludge, digested sludge, water and hydrolyzed sludge.

C. Stainless steel piping for the system listed below shall be designed for the following conditions:

1. System: [_____]
   a. Material: Type [304L] [316L]
   b. Operating [Air] Pressure: [_____]
   c. Test [Air] Pressure: [_____]
   d. Flow Velocity: [_____]
   e. Temperature: [_____]

Comment [TJN1]: To be determined by the THP System Supplier

1.07 DELIVERY, STORAGE AND HANDLING

A. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe and fittings. Pipe and fittings shall not be dropped. Pipe and fittings shall be examined before installation and no piece shall be installed which is found to be defective.

B. In handling the pipe, wide cushioned slings or other devices and methods acceptable to the Engineer shall be used. No uncushioned ropes, chairs, wedges or levers shall be used in handling the pipe, fittings and couplings.

C. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe by the Contractor, at the Contractor's own expense. All pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until they are put into service.

PART 2 PRODUCTS

NOTE: Edit the following to fit project. Add or delete as required. Select ASTM A312 for heat treated pipe (for highly corrosive application) or ASTM A778 for low to moderate corrosive or temperature conditions.

2.01 MATERIALS

A. All stainless steel pipe and fittings 8-in and larger shall be fabricated from stainless steel sheet and conform to ASTM A312Type 304L. All stainless steel pipe and fittings 6-in and less shall be fabricated from stainless steel sheet and conform to ASTM A312Type 316L. Carbon content of Type 316L material shall be 0.03 percent maximum. Finish shall be No. 1 or No. 2B.

B. Pipe shall be die-formed or rolled true to dimension and round. Tolerances for length, inside and outside diameter and straightness shall conform to ASTM A530. The two edges of sheet shall be brought to line so as not to leave a shoulder on the inside of the pipe. Ends of pipe and fittings shall be perpendicular to the longitudinal axis. Longitudinal seams on pipe and fittings shall be welded by either the tungsten gas or the metallic-gas method. The interior welds shall be smooth, even and shall not have an internal bead higher than 1/16-in. All pieces shall be

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marked with gauge and type of stainless steel and with the initials of the inspector marked on the inside of each piece, at each end.

1. Use procedure to calculate required wall thickness for internal pressure (positive or negative) and external loads. See Chapter 4 of AWWA M-11 using applicable coefficients for type of stainless steel selected. Refer to Table below.

PIPE	TENSILE STRENGTH	MIN. YIELD STRENGTH
TYPE 304L	70,000 PSI	25,000 PSI
TYPE 304	75,000 PSI	30,000 PSI
TYPE 316L	70,000 PSI	25,000 PSI
TYPE 316	75,000 PSI	30,000 PSI

2. Select wall thickness to specify by using either gauge, schedule or thickness in inches that is closest to, but not less than the calculated thickness.

C. Pipe and fittings shall be supplied with the following wall thicknesses:

WALL THICKNESS			
SCHEDULE PER	*		
kmlDIAMETER (INCHES)	ANSI B36.19	GAUGE	INCHES
Less than [_____]	[10S]	[40S]	[__]
[_____] to [_____]	[10S]	[40S]	[__]
[_____] to [_____]	[10S]	[40S]	[__]
Greater than [__]	[10S]	[40S]	[__]
* Not thinner than 16 gauge.			

Comment [TJN2]: To be determined after selection of THP System Supplier

D. Fittings shall be smooth curve type up to 18-in diameter and mitered type 20-in diameter and greater. Fittings shall conform to ANSI B16.9.

E. Flanges for pipe 4-in and smaller shall be of the type of stainless steel as the pipeline, and shall be welded directly to the pipe end, and shall be drilled to the 125 lb ANSI B16.1 standard. Flanges for pipe larger than 4-in shall have stub ends or rolled angle rings of the type of stainless steel as the pipeline welded to the pipe end, with suitable gaskets between the mating surfaces and joined through the use of 125 lb rated back-up flanges, drilled to ANSI B16.1, and made of materials as shown on the Drawings Where the pipe stub is to pass through a sleeve during installation, a split-type back up flange shall be used. Bolts, washers, nuts and other hardware for flange bolting shall be Type [304] [316] stainless steel.

Comment [TJN3]: To be determined after the selection of the THP System Supplier

F. [Gaskets for flanged connections shall be a minimum of 1/16-in thick and shall be rubber, hypalon, teflon, BUNA-N, SBR, NBR or viton]. [Gaskets for Ozone, Ozone off-gas or Ozonated water pipe shall be teflon or hypalon.]

Comment [TJN4]: To be determined after the selection of the THP System Supplier

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G. Shop fabricated multiple output headers may be used in lieu of individual flanged fittings.

H. Wall pipes shall have integral shop welded wall stops.

I. All stainless steel pipe and fittings shall be pickled at the point of manufacture, scrubbed and washed until all discoloration is removed in accordance with ASTM A380.

J. Pipe ends shall be prepared for couplings or other type ends where required by transport and handling limitations, where required by the support layout requirements and where noted on the Drawings. Plain end pipe may be coupled with "Pressfit"-style connectors, for pipe/tubing sizes 1-1/2-in and smaller, manufactured by the Victaulic Co. or by the use of grooved end couplings. Grooving (or built-up ends for Schedule 5s or 10s pipe) shall be of the coupling manufacturers standard type. [Split ring, grooved end couplings shall not be used for Ozone, Ozone off-gas or Ozonated water lines.] Contractor is responsible for ensuring rigidity of joints where required. All normal pipe joints at valves, bends, etc, shall be flanged, drilling per ANSI B16.1, Class 125.

K. Shop welding of fabrications shall be done according to the procedures and by welders certified per ASME Section IX. Welds shall be by an inert gas shielding process using only extra low carbon filler metals. Welds shall have a bead height of no more than 1/16-in. Butt welds shall have 100 percent penetration to the interior or backside of the weld joint. Cross-sectional thickness of welds shall be equal or greater than that of the parent metal.

L. Where shown on the Drawings or where approved by the Engineer, plain end pipe shall be joined by all stainless steel flexible couplings. Sleeve type couplings shall be of the Type 316L stainless steel and shall be Style 38 as manufactured by Dresser Manufacturing Division of Dresser Industries; coupling 411 as manufactured by Smith Blair, Inc. or equivalent couplings manufactured by Depend-O-Lok Co.

M. Where shown on the Drawings or where approved by the Engineer, flanged coupling adaptors shall be used to connect plain end pipe to equipment, fittings and valves. Flanged coupling adaptors shall be of the Type 316L stainless steel and shall comply with AWWA C207. Flanged coupling adapters shall be manufactured by Dresser Manufacturing Division of Dresser Industries; Smith Blair, Inc. or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. All pipe and fittings shall be installed true to grade and alignment and pipe anchorage and/or restraint shall be provided where required. Manufacturer's instructions shall be strictly followed.

B. All pipe and fittings shall be protected from dirt, dust, oil, grease and other foreign matter during installation to prevent damage to pipe and to assure no foreign matter is left in the piping.

C. To assemble the joints in the field, thoroughly clean all joint surfaces and gaskets, if any, with soapy water before assembly. Bolts shall be tightened alternately, evenly to the manufacturer's specified torques. Under no condition shall extension wrenches or pipe-over-handle ratchet wrenches be used to secure greater leverage. All electrical bonding or insulation shall be installed as joints are made up.

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D. Fittings, in addition to those shown on the Drawings, shall be provided if required. Due consideration shall be given to thermal expansion/contraction over a temperature range of 200 degrees F.

E. When cutting of pipe is required, the cutting shall be done by machine neatly, without damage to the pipe. Cut ends shall be smooth and at right angles to the axis of the pipe.

F. After installation, stainless steel pipe lines shall be washed clean with steam or hot water to remove any foreign material picked up during transport.

3.02 JOINING MECHANICAL AND RESTRAINED JOINTS

A. Mechanical joints shall be in accordance with the "Notes on Methods of Installation" under AWWA C111 and the instructions of the manufacturer.

B. Restrained joint pipe and fittings shall be installed in the locations shown on the Drawings and as acceptable to the Engineer.

3.03 JOINING FLANGED JOINTS

A. Flanged joints shall be made with gasket, bolts and nut bolts stud with a nut on each end, or studs with nuts where the pipe is tapped. The number and size of bolts shall conform to the same standard requirements as the flange.

3.04 FIELD WELDING

A. Welding in the field shall be done only if approved by the Engineer. Field welds shall be made by welders certified under ASME Section IX and be equal in all respects to shop welds. After field welding has been done, all joints shall be thoroughly cleaned and buffed using deburring and finishing wheels.

3.05 FIELD PAINTING

A. Final field painting is included in Section 09902 except that for all stainless steel pipe, only bands, labels and arrows rather than full pipe painting will be required.

3.06 DISINFECTION AND CLEANUP

A. After installation, completed lines shall be cleaned with Oakite deoxidizer or similar deoxidizer as recommended by the manufacturer to remove all foreign matter, construction stains or shop markings. Cleaned lines shall be rinsed clear with steam or hot water.

3.07 FIELD TESTING

A. Field Testing of the pipe is specified in Section 01445.

END OF SECTION

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NOTE: Problems or comments resulting from the use of this Section such as changes in mfr. model nos., mfr. no longer exists, new or incorrect material application, or problems with regulatory agencies should be forwarded to the Cambridge Office, in care of Jim Molinari. Refer to and use Feedback Form located in Division 0 MASTERS for comments concerning possible revisions to this CDMSpec Master.

ATTACHMENT A

STAINLESS STEEL PIPE WALL THICKNESS GUIDE

NOTE: This information is for guidance in selecting wall thickness. It should not be used without first calculating minimum wall thickness based on design conditions of internal pressure and external loads. Thickness should be specified either as schedule 5S, 10S, 40S or 80S gauge or as a wall thickness.

PRESSURE 0 TO 25 PSIG

Pipe or Tube Diameter	Wall Thickness *
10-in and less	16 Gauge (0.064-in)
12-in	14 Gauge (0.079-in)
14-in	12 Gauge (0.109-in)
16-in	12 Gauge (0.109-in)
18-in	11 Gauge (0.124-in)
24-in	10 Gauge (0.138-in)

PRESSURE TO 150 PSI AT 200 DEGREES F.

Tube OD or Pipe Diameter	Tube Wall Thickness *	Pipe Wall Thickness *
3 to 6	14 Gauge (0.079-in)	Schedule 5 (0.065 to 0.109)**
8 to 12	12 Gauge (0.109-in)	12 Gauge (0.109-in)
14 to 16	11 Gauge (0.124-in)	11 Gauge (0.124-in)
18 to 20	10 Gauge (0.138-in)	10 Gauge (0.138-in)
24	8 Gauge (0.168-in)	8 Gauge (0.168-in)
30	3/16-in	3/16-in
36	1/4-in	1/4-in

*Verify thickness in inches and gauge thickness. Some manufacturers use different gauge definitions.

**Depends on diameter.

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SECTION 15072
DUCTILE IRON PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required, install, disinfect and test ductile iron pipe and fittings for non-buried plant mechanical piping as shown on the Drawings and as specified herein.

B. Mechanical piping shall include all piping and fittings installed above grade, in utility tunnel or gallery and shall exclude pipe in valve vaults, manholes, cleanouts and similar yard structures.

C. Mechanical piping shall be installed as shown on the Drawings. Provide pipe supports, hangers and couplings as required to achieve a complete pipe system.

D. Where the word "pipe" is used, it shall refer to pipe, fittings, or appurtenances unless otherwise noted.

1.02 RELATED WORK

A. Pipe penetrations are included in Section 01172.

B. Pipeline testing, cleaning and disinfection is included in Section 01445.

C. Delivery, Storage and Handling is included in Section 01600.

D. Buried piping and appurtenances are included in Division 2.

E. Painting is included in Division 9.

F. Piping – General Requirements are included in Section 15051.

G. Valves and Appurtenances are included in Section 15100.

H. Piping Specialties are included in Section 15120.

I. Pipe Hangers and Supports are included in Section 15140.

J. Thermal Insulation is included in Section 15250.

K. Electric heat tracing is included in Section 15257.

1.03 SUBMITTALS

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

1. Tabulated layout drawings showing actual pipe lengths, diameters, fittings and appurtenances.

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2. Prior to shipment of pipe, submit a certified affidavit of compliance from the pipe manufacturer stating that the pipe, fittings, gaskets, linings and exterior coatings for this project have been manufactured and tested in accordance AWWA and ASTM standards and requirements specified herein.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM C150 - Standard Specification for Portland Cement.

B. American National Standards Institute (ANSI)

1. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form).

2. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125 and 250.

3. ANSI B18.2 - Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws.

C. American Water Works Association (AWWA)

1. AWWA C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings

2. AWWA C110 - Ductile-Iron and Gray-Iron Fittings. (3-in Through 48-in (80mm Through 1200mm) for Water)

3. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

4. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.

5. AWWA C116 – Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.

6. AWWA C150 - Thickness Design of Ductile-Iron Pipe.

7. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.

8. AWWA C153 – Ductile-Iron Compact Fittings for Water Service.

9. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.

10. AWWA C606 - Grooved and Shouldered Joints.

11. AWWA C651 - Disinfecting Water Mains.

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

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1.05 QUALITY ASSURANCE

A. Each length of ductile iron pipe supplied for the project shall be hydrostatically tested at the point of manufacture to 500 psi for a duration of 10 seconds per AWWA C151. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture of the pipe wall. Certified test results shall be furnished in duplicate to the Engineer prior to time of shipment.

B. All ductile-iron pipe and fittings to be installed under this project shall be inspected and tested at the foundry as required by the standard specifications to which the material is manufactured. Furnish in duplicate to the Engineer sworn certificates of such tests and their results prior to the shipment of the pipe.

C. All pipe and fittings to be installed under this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory selected by the Owner, at the Owner's expense.

D. Inspection of the pipe and fittings will also be made by the Engineer or representative of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the specified requirements, even though sample pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall be removed from the job.

E. All pipe and fittings shall be permanently marked with the following information:

1. Manufacturer, date.

2. Size, type, class, or wall thickness.

3. Standard produced to (AWWA, ASTM, etc).

1.06 DELIVERY, STORAGE AND HANDLING

A. See Section 01600 for general requirements.

B. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe or coatings. Under no circumstances shall the pipe be dropped or skidded against each other. Slings, hooks, or pipe tongs shall be padded and used in such a manner as to prevent damage to the exterior surface or internal lining of the pipe.

C. Materials, if stored, shall be kept safe from damage. The interior of all piping, fittings and other appurtenances shall be kept free from dirt or foreign matter at all times.

D. Pipe ends, including flange faces, shall be protected from damage. All openings shall be adequately covered with end caps, plugs, or a minimum 1/2 inch thick wooden blind flange secured in place with steel fasteners to prevent entrance of dirt, water and debris, and keep the pipe interior clean.

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E. Pipe shall not be stacked higher than the limits recommended by its manufacturer. The bottom tier shall be kept off the ground on timbers, rails, or concrete. Stacking shall conform to manufacturer's recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe

1. Ductile iron pipe shall conform to AWWA C115 and C110. Flanged and groove end pipe shall be Thickness Class 53 as per AWWA C150.

2. Pipe shall be supplied in standard lengths as much as possible.

3. Ductile iron pipe shall be as manufactured by U.S. Pipe and Foundry Company, Inc.; American Cast Iron Pipe Company; Clow Water System Company; or equal.

B. Joints

1. Ductile iron pipe shall have flanged or grooved joints. Flanges shall be flat face type, unless otherwise noted, meeting the requirements of ANSI B16.1 Class 125.

2. Flange gasket shall be full face type per AWWA C111 to provide positive sealing for the flanged ductile iron joints. Thickness shall be 1/8-in unless otherwise indicated. The gasket materials for potable water pipe shall be certified by NSF61. Gasket materials shall be as follows.
   a. Fats, oils and grease (FOG): Nitrile (NBR)
   b. Potable water: Styrene butadiene (SBR)
   c. Sanitary sewage & sludges: Styrene butadiene (SBR)

3. Assembly bolts shall be square headed carbon steel machine bolts with hexagon nuts per ANSI B18.2. Thread shall conform to ANSI B1.1. Bolt length shall be such that after joints are assembled, the bolts shall protrude through the nuts, but not more than 1/2-in. [Steel flanges in conformance with AWWA C207, Class D, may be mated to iron valves, fittings, or other parts having either integral Class 125 iron flanges or screwed Class 125 companion flanges. When such construction is used, the raised face on mating flanges shall be removed.]

4. Grooved couplings shall be as specified in Section 15120.

5. Sleeve type couplings shall be as specified in Section 15120.

6. Flanged coupling adaptors shall be as specified in Section 15120.

C. Fittings

1. Pipe fittings shall be ductile iron with a minimum pressure rating of 250 psi. Fittings shall meet the requirements of AWWA C110 as applicable. Fittings shall have the same pressure rating, as a minimum, of the connecting pipe.

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D. Interior Lining

1. Ductile iron pipe and fittings shall have the same type of lining as specified or indicated on the Drawings.

2. Ductile iron pipe and fittings for plant water and potable water shall have a cement mortar lining and asphaltic seal coat in accordance with AWWA C104. The cement shall be Type II per ASTM C150.

3. Ductile iron pipe and fittings for wastewater and sludges shall be lined with a ceramic-filled amine-cured epoxy, Protecto 401 by Induron. The lining thickness shall be 40 mils minimum. Application shall be performed by an applicator approved by the coating manufacturer, in accordance with manufacturer's instructions and under controlled conditions at the applicator's shop or the pipe manufacturer's plant. Applicator shall submit a certified affidavit of compliance with manufacturer's instructions and requirements specified herein.

4. All interior linings for potable water use shall be certified by NSF 61.

E. Exterior Coatings

1. Unless otherwise specified, all coatings shall be shop applied with "hold-backs" provided as required at pipe and fitting ends for satisfactory installation for joint connections in the field. Provide all necessary coating materials to perform field coating applications at joints. Unless otherwise noted, field applied coating material shall be compatible with or equal to the shop applied material. Field repair of pipe with damaged coating shall receive prior approval of the Engineer. If, in the opinion of the Engineer that the coating damage is beyond repair the pipe shall be replaced at the expense of the Contractor. All flange bearing surfaces shall be uncoated.

2. Unless otherwise specified, all exposed exterior ferrous surfaces shall be painted with an applicable paint system as specified under Division 9. Surface preparation and application thereof shall be in conformance with applicable provisions of Division 9.

F. Pipe Hangers and Supports

1. Pipe hangers and supports shall be provided at suitable distance along the pipeline regardless of whether they are shown or not shown on the Drawings.

2. Pipe hangers and supports shall be as specified in Section 15140.

G. Thermal Insulation

1. Insulation shall be provided as indicated on the Drawings and in Section 15250.

2. Pipe insulation shall be as specified in Section 15250.

H. Electric Heat Tracing

1. Electric heat tracing shall be provided as indicated on the Drawings and in Section 15257.

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2. Electric heat tracing shall be as specified in Section 15257.

PART 3 EXECUTION

3.01 PIPE INSTALLATION

A. General

1. All piping and fittings shall be installed true to alignment and rigidly supported. Anchorage shall be provided where required. Any damage to linings shall be repaired to the satisfaction of the Engineer before the pipe is installed. Each length of pipe shall be cleaned out before installation. All of manufacturer's recommendations shall be complied with.

2. The deflection at joints shall not exceed that recommended by the pipe manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided, if required, in areas where conflict exists with the existing facilities.

3. When pipe cutting is acceptable to the Engineer, the cutting shall be done by abrasive saw, leaving a smooth cut at right angles to the axis of the pipe. Any damage to the lining shall be repaired to the satisfaction of the Engineer. Field cut ends shall be sealed with an approved epoxy coating in accordance with the manufacturer's instructions. If the pipe is to be used to carry potable water, the epoxy coating shall be approved by NSF 61.

4. Ductile iron and fittings shall be installed in accordance with requirements of AWWA C600 modified.

B. Jointing

1. Flanged joints shall be made using gaskets, bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts shall conform to the same ANSI Standard as the flanges.

2. Bolts in flanged joints or mechanical joints shall be tightened alternately and evenly.

3. Sleeve type couplings and grooved joints using split ring couplings shall be installed in accordance with the procedures recommended by their respective manufacturers.

C. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit a certification stating that such requirements have been complied with.

D. Sleeves of proper size shall be installed for all pipes passing through floors or walls. Sleeves shall be installed as shown on the Drawings. Where indicated on the Drawings or required for liquid or gas-tightness, the pipe shall be sealed with a mechanical seal similar to Link-Seal as manufactured by Thunderline Corporation, or equal, in accordance with Section 01172.

E. Sleeves and wall pipes shall have thrust collar located at the mid-depth of wall.

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F. Concrete inserts for hangers and supports shall be furnished and installed as recommended by the manufacturer as shown on the Drawings or as specified herein. The inserts shall be set in accordance with the requirements of the piping layout and their locations verified from approved piping layout drawings and the structural drawings.

G. Refer to Section 15140 for additional pipe hanger, support, and restraint requirements.

3.02 TESTING

A. All piping shall be subject to acceptance tests. Provide all necessary utilities, labor and equipment for flushing and testing and dispose all waste after the test including water.

B. All pipe and fittings shall be pressure tested in accordance with Section 01445.

C. Correct any leakage and repair any damage to the pipe and pipe appurtenances or to any structures resulting from, or caused by tests. All leaks shall be repaired and lines retested.

3.03 CLEANING

A. Clean the pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, or other material which may have entered during the construction period. All debris shall be removed from the pipeline. The lowest segment outlet shall be flushed last to assure debris removal.

3.04 DISINFECTION

A. Ductile iron pipe used for potable water service shall be disinfected after cleaning. Provide all necessary equipment and labor for the disinfection.

B. Disinfection shall be in accordance with Section 01445.

3.05 PIPE MARKING & FIELD PAINTING

A. Pipes shall be field painted and marked in accordance with Section 09902.

END OF SECTION

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SECTION 15100
VALVES AND APPURTENANCES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required, and install complete and ready for operation, all non-buried valves and appurtenances as shown on the Drawings and as specified herein.

B. The equipment shall include, but not be limited to, the following:

1. Valve actuators (manual)
2. Valve actuators (powered)
3. Gate valves and appurtenances for yard piping
4. Gate valves for inside service
5. Butterfly valves
6. Butterfly valves (energy efficient)
7. Plug valves
8. Ball valves
9. Check valves
10. Rubber flapper swing check valves
11. Knife gate valves
12. Combination air & vacuum relief valves
13. Pinch valves
14. Diaphragm valves
15. Globe valves
16. Needle valves
17. Pressure regulating valves
18. Solenoid valves
19. Thermoplastic valves

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20. Fire hydrants
21. Yard hydrants
22. Quick connect couplings
23. Strainers
24. Rotameters
25. Diaphragm Seals
26. Mechanical Type Seals
27. Hose End Valves
28. Flap Valves
29. Mud Valves
30. Expansion Joints

1.02 RELATED WORK

A. Pipe testing and disinfection for potable water systems are included in Section 01445.

B. Buried valves and appurtenances are included in Division 2.

C. Process piping is included in the respective Sections of Division 15.

D. Shop and finish painting are included in Division 9.

E. Instrumentation and control work, except as specified herein, is included in Division 13. Instrumentation and controls provided in this section shall adhere to Instrumentation and Control Specifications Sections in Division 13.

F. All valves for the sludge digester gas system are included in Division 13.

G. Piping specialties are included in Section 15120.

H. Pipe Hangers and supports are included in Section 15140.

I. Thermal insulation is included in Section 15250.

J. Electric heat tracing is included in Section 15257.

K. Valves on all HVAC and Plumbing systems are included in their respective Sections of Division 15.

L. Electrical is included in Division 16.

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M. Certain items similar to those specified in this Section may be specified to be furnished and installed with individual equipment or systems. In case of a conflict, those individual equipment or system requirements shall govern.

N. Electric valve operators of all types, rate of flow controllers (including modulating valves and operators) and other types of valves which are part of the automated instrumentation (such as some solenoid valves) if not included herein are included in Division 13. Valve operators shall, however, be mounted at factory on valves as specified herein, as part of the work of this Section.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, copies of all materials required to establish compliance with this Section. The first submittal shall be the valve schedule described in Article 1.09. Approval of the valve schedule submittal is required prior to Contractor's submittal of any of the equipment in this Specification. Subsequent equipment submittals shall include at least the following:

1. Valve tag number(s).

2. Manufacturer and supplier.

3. Address at which the equipment will be fabricated or assembled.

4. Certified drawings showing all important details of construction and dimensions.

5. Descriptive literature, bulletins, and/or catalogs of the equipment.

6. All information required by Section 01100.

7. The total weight of each item.

8. A complete total bill of materials.

9. A list of the manufacturer's recommended spare parts.

10. Additional submittal data, where noted with individual pieces of equipment.

11. Individual electrical control schematics and wiring diagrams for each valve operator with external interfaces, identified exactly as detailed on Electrical and Instrumentation Drawings. Standard catalogue cut sheets that show typical wiring diagrams only are not acceptable. Valve actuators shall be coordinated with electrical requirements shown on Drawings and valves as specified herein.

B. Test Reports:

1. Provide certified hydrostatic test data, per manufacturer's standard procedure or MSS-SP-61 for valves.

C. Certificates:

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1. For each valve specified to be manufactured, tested and/or installed in accordance with AWWA and other standards, submit an affidavit of compliance with appropriate standards, including certified results of required tests and certification of proper installation.

D. Manufacturer's Installation and Application Data

E. Operation and Maintenance Data

1. Operating and maintenance instructions shall be furnished to the Engineer as provided in Section 01730. The instructions shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A48 - Standard Specification for Gray Iron Pipe.

2. ASTM A126 - Standard Specification for Gray Iron Casting for Valves, Flanges and Pipe Fittings.

3. ASTM A436 - Standard Specification for Austentic Gray Iron Castings.

4. ASTM A536 - Standard Specification for Ductile Iron Castings.

5. ASTM B30 - Standard Specification for Copper-Based Alloys in Ingot Form.

6. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

7. ASTM G8 - Standard Test Methods for Cathodic Disbonding of Pipeline Coatings.

B. American Society of Mechanical Engineers (ASME)

1. ASME B2.1 - Specifications, Dimensions, Gauging for Taper and Straight Pipe Threads (except dry seals).

2. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.

C. American Water Works Association (AWWA)

1. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

2. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.

3. AWWA C502 - Dry-Barrel Fire Hydrant.

4. AWWA C505 - Rubber-Seated Butterfly Valves.

5. AWWA C508 - Swing-Check Valves for Waterworks Service 2-in (50-mm) Through 24-in (600mm) NPS.

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6. AWWA C800 - Underground Service Line Valves and Fittings.

D. American National Standards Institute (ANSI)

E. Factory Mutual (FM)

F. The Society for Protective Coatings (SSPC)

1. SSPC SP5 - Surface Preparation Specification No. 5 White Metal Blast Cleaning.

G. National Electrical Manufacturers Association (NEMA)

H. Underwriters Laboratories (UL)

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. Qualifications:

1. Valves and appurtenances shall be products of well established firms who are fully experienced, minimum ten years, reputable and qualified in manufacture of particular equipment to be furnished.

2. Equipment shall be designed, constructed and installed in accordance with best practices and methods and shall comply with this Section as applicable.

3. Units of the same type shall be the product of one manufacturer.

4. All 480 volt motor actuators shall be product of one manufacturer, Contractor shall coordinate this requirement with vendors who supply actuated valves as part of systems specified in Division 11, 13 and 15.

B. Certifications:

1. Manufacturers shall furnish an affidavit of compliance with Standards referred to herein as specified in Article 1.03C above. Refer to PART 3 for testing required for certain items in addition to that required by referenced standards.

C. Provide services of a qualified and factory-trained service representative of manufacturer to provide operational and maintenance instruction, for a one day, eight hour period for each type of the following equipment:

1. Valve motor operators.

2. Pressure regulating valves.

3. Air release, air and vacuum valves.

4. Surge relief valves.

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5. Pinch valves.

6. Hydraulic cylinder actuators.

D. Inspection of units may also be made by Engineer or other representative of Owner after delivery. Equipment shall be subject to rejection at any time due to failure to meet any of specified requirements, even though submittal data may have been accepted previously. Equipment rejected after delivery shall be marked for identification and shall be removed from job site at once.

1.06 SYSTEM DESCRIPTION

A. Equipment and materials specified herein are intended to be standard for use in controlling flow of water, wastewater, sludge, air, and chemicals as noted on Drawings.

B. Valves, appurtenances and miscellaneous items shall be installed as shown on Drawings and as specified, so as to form complete workable systems.

C. Unless otherwise noted, powered valve operators shall have:

1. Valves larger than 3-in: electric operators 460 Volt, 3 Phase, 60 Hz.

2. Valves 3-inch and under: electric operators, 120 Volt, 1 Phase, 60Hz.

3. Solenoid valves: 120 volt, single phase, 60 Hz, NEMA 4 enclosure, continuous duty Class F coils and manual operator. Solenoid valves for seal water systems shall be “fail open” design; others shall be “fail closed” unless otherwise noted on the Drawings or in the Instrumentation specifications.

1.07 DELIVERY, STORAGE AND HANDLING

A. Reference is made to Section 01600 for additional information.

B. Packing and Shipping:

1. Care shall be taken in loading, transporting and unloading to prevent injury to the valves, appurtenances, or coatings. Equipment shall not be dropped. Valves and appurtenances shall be examined before installation and no piece shall be installed which is found to be defective. Damage to the coatings shall be repaired as acceptable to Engineer.

2. Prior to shipping, ends of valves shall be acceptably covered to prevent entry of foreign material. Covers shall remain in place until after installation and connecting piping is completed.
   a. Valves 3-in and larger shall be shipped and stored on site until time of use with wood or plywood covers on each valve end.
   b. Valves smaller than 3-in shall be shipped and stored as above except that heavy cardboard covers may be used on the openings.
   c. Rising stems and exposed stem valves shall be coated with a protective oil film which shall be maintained until the valve is installed and put into use.
   d. Corrosion in evidence at the time of acceptance by the Owner shall be removed, or the valve shall be removed and replaced.

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C. Storage and Protection:

1. Special care shall be taken to prevent plastic and similar brittle items from being directly exposed to the sun, or exposed to extremes in temperature, to prevent deformation. See the individual piping sections and manufacturer's information for further requirements.

1.08 MAINTENANCE

A. Special tools and the manufacturer's standard spare parts, if required for normal operation and maintenance, shall be supplied with the equipment in accordance with Sections 01600 and 01730 and where noted, as specified herein. These special tools and spare parts shall be packaged and labeled in accordance with Section 01600.

B. Provide one operation and maintenance manual for each type of valve and operator supplied under this Section in accordance with Section 01730.

C. In each operation and maintenance manual, provide a list of all spare and replacement parts with individual prices and location where they are available.

1.09 VALVE DESIGNATIONS AND SCHEDULE

A. Prior to the first valve submittal, Contractor shall submit a detailed valve schedule.

B. Valves shall be identified by a unique valve tag as identified in the valve schedule prepared by the Contractor. Specific type of valve to be used will be identified by symbol and/or call out on Drawings. Contractor shall identify each valve by its assigned tag number on shop drawings and equipment submittals.

C. Contractor shall refer to the P&IDs and mechanical plans for type of each valve called out by abbreviation or drawing symbol. The valve schedule shall list process valves to be furnished along with Contract Drawing P&IDs edited electronically which shall include valve tag numbers prepared by Contractor identifying each valve.

D. This valve schedule shall NOT include valves furnished under Division 2 or in Plumbing and HVAC sections of Division 15.

E. Valve schedule shall include: valve tag number; valve designation; P&ID sheet reference; valve size; end connections and operator type. Valve tag convention shall be four digits long, and numbering shall be linked to the P&ID Sheet on which it is shown. Identical valves in same position in parallel processes (EX. Pump inlet/outlet isolation valves where there are three parallel pumps of same type) shall have same tag number followed by a hyphen and quantifier - 1, 2, 3 etc. Where electric, hydraulic or pneumatic actuators are supplied their type shall be so noted with an E, H or P. Modulating duty actuators shall be noted with an M following the actuator type notation. An excerpt of an EXAMPLE schedule is as follows:

Valve Tag	Designation	P&ID Sheet	Size	Ends	Operator	Notes
1000-1	BFV1	I-1	8-in	Flanged	Gear/Handwheel	Extra description as necessary
1000-2	BFV1	I-2	8-in	Flanged	Gear/Handwheel	
1005	PV1	I-3	6-in	Flanged	EM	

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PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Reference is made to Division 1 for additional requirements, including nameplates, provisions for temporary pressure gauges, protection against electrolysis and anchor bolts.

B. Use of a manufacturer's name and/or model or catalog number is for purpose of establishing standard of quality and general configuration desired.

C. Valves and appurtenances shall be of size shown on the Drawings or as noted and as far as possible equipment of same type shall be identical and from one manufacturer.

D. Valves and appurtenances shall have name of maker, nominal size, flow directional arrows, working pressure for which they are designed and standard referenced, cast in raised letters or via riveted stainless steel nameplate upon some appropriate part of the body.

E. Unless otherwise noted, items shall have a minimum working pressure of 150 psi or be of same working pressure as pipe they connect to, whichever is higher and suitable for pressures noted where they are installed.

F. Joints, size and material - unless otherwise noted or required by Engineer:

1. Except where noted, joints referred to herein shall be of same type, nominal diameter, material and with a minimum rating equal to pipe or fittings they are connected to.

2. Valves and appurtenances shall be of same nominal diameter as pipe or fittings they are connected to.

3. Valves exposed to view, or in vaults:
   a. Plastic valves in chemical service - solvent cement, or flanged ends.
   b. 3-in and smaller - threaded ends- unless noted otherwise herein or on Drawings.
   c. 4-in and larger - flanged ends.

G. Provide special adaptors as required to ensure compatibility between valves, appurtenances, and adjacent pipe.

H. No alternative materials will be considered for approval unless complete documentation is provided regarding their satisfactory long-term use in similar conditions; in addition, the consideration of any substitution will be considered only if superiority of proposed materials is the intent of substitution, and only if sufficient evidence is provided to document that superiority.

2.02 VALVE ACTUATORS - GENERAL/ MANUAL

A. Geared actuators shall be suitable for all weather service, with mechanical shaft seals, shall be permanently greased, or shall have provisions for greasing. Actuators for submerged duty shall be so rated, with certification by manufacturer for submerged service.

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B. Valve manufacturer shall supply, mount, and test all actuators on valves at factory. Valves and their individual actuators shall be shipped as a unit.

C. Unless otherwise noted on Drawings, valves shall be manually actuated; non-buried valves shall have an operating wheel, handle or lever mounted on operator; those with operating nuts shall have a non-rising stem with an AWWA 2-in nut. At least two tee handles shall be provided for operating nuts. Unless otherwise noted, operation for valves shall be CCW open.

D. Manually actuated butterfly valves 6 inches and smaller for fluid service shall have a 10 position, spring retained ratcheting handle. Handle shall be fusion bonded epoxy coated steel or cast iron, hardware, spring and ratcheting plate shall be Type 316 stainless steel. Manually actuated butterfly valves for air service 6 inches and smaller shall have a memory stop handle with infinite throttling position capability. Memory stop plate and hardware shall be Type 316 stainless steel.

E. Except as otherwise shown on Drawings or specified herein, valves 3-in diameter or larger, with valve hand wheel center line located 7-ft or more above operating floor, shall be provided with chain wheel operators complete with chain guides and hot dipped galvanized steel chain, which loop within 4-ft of operating floor. These requirements shall supersede positioning lever actuator requirements of manual butterfly valves 6 inch and smaller.

F. Actuators shall be capable of moving valve from full open to full close position and in reverse and holding valve at any position part way between full open or closed.

G. Each operating device shall have cast on it the word “OPEN” and an arrow indicating direction of operation.

H. Floor boxes for operating nuts recessed in concrete shall be standard cast iron type, cast-in-place, with fastening top, and Type 316 stainless steel hardware.

I. Stem guides shall be of the adjustable wall bracket type, bronze bushed, with maximum spacing of 10-ft as manufactured by Clow; Rodney Hunt or equal. Extended operating nuts and/or stems shall have universal joints and pin couplings, if longer than 10-ft and a rating of at least five times the maximum operating torque. Stem adaptors shall be provided.

J. Where required by installation, or as specified, provide the following: extended stem; floor stand and handwheel; position indicator and etched or cast arrow to show direction of rotation to open the valve; resilient, moisture-resistant seal around stem penetration of slab.

K. Gear Actuators:

1. Unless otherwise noted, gear actuators shall be provided for the following: plug and ball valves larger than 3-in diameter; butterfly valves larger than 6 inch diameter; where specified and/or indicated on Drawings; where manual operator effort is greater than 40 lbs rim pull.

2. Actuators shall be capable of being removed from valve without dismantling the valve or removing valve from the line.

3. Gear actuators for quarter turn valves shall be of worm or helical worm gear type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on

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output shaft. Where shown on Drawings, a two inch cast iron operating nut shall be provided. Actuators shall conform to AWWA C504 except where more stringent requirements are provided hereinafter. Gearing shall be machine cut steel designed for smooth operation. Bearings shall be permanently lubricated, with bronze bearing bushings provided to take thrusts and mechanical shaft seals to contain lubricants. Housings shall be sealed to exclude moisture and dirt, allow reduction mechanisms to operate in lubricant and be constructed of cast iron, ASTM A 126, Grade B, or of ductile iron, ASTM A 536. Gear housing bodies for thermoplastic valves may be cast aluminum or fabricated steel to reduce weight. Gear actuators shall indicate valve position and have adjustable stops.

4. Where indicated on Drawings, gear actuators for butterfly valves shall be of travelling nut type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on output shaft. Unless noted they shall conform to AWWA C504. Stem shaft shall be machine cut alloy steel, nut and cross head shall be bronze, lever shall be ductile iron. Nut Actuators for valves 24-in and smaller shall be slotted lever design, actuators for valves greater than 24 inch shall be link and lever design. Mechanism shall be lubricated with water resistant extreme pressure NLGI No. 2 grease. Bevel gear reduction box shall be mounted on the actuator when required to meet specified manual operating effort requirements Gear actuators shall have mechanical, external indication of valve position and have adjustable threaded stops secured to the stem with spring pins. Stop shall be capable of withstanding 450-fts-lb of input torque. Stop adjustment requiring shims are not acceptable.

5. Manual Input torque to produce required valve operating torque for worm and travelling nut gear operators shall not exceed 80 ft-lbs. In addition, hand wheel rim pull shall not exceed 20 lbs for valve sizes up to 12 inches, 40 lbs for valve size between 14 and 20 inches, 60 lbs for valve size 24 and greater. Minimum hand wheel size shall be 8 inches for up to 12 inch valve size, 12 inches for up to 16 inch valve size, 18 inches for up to 20 inch size.

6. Gear actuators for multi turn valves shall be of bevel or spiral bevel type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on output shaft. Gearing shall be machine cut steel designed for smooth operation. Bearings shall be permanently grease lubricated, with dual anti-friction ball bearings on output shaft and mechanical shaft seals to contain lubricants. Output flange of primary gear reducer shall be designed to meet an appropriate MSS or ISO standard to allow mounting to secondary gear reducer. Ring gear shall ride on ball bearings. Stem nut shall be bronze alloy, shouldered, and ride on needle bearings. Housing components shall be o-ring sealed to exclude moisture and dirt, constructed of cast iron, ASTM A126, Grade B, or of ductile iron, ASTM A 536. Gear housing bodies for thermoplastic valves may be cast aluminum or fabricated steel to reduce weight. Manual operator input effort to the hand wheel shall be a maximum of 30 lbs for operating the valve from full open to full close, under any conditions. Maximum hand wheel size shall be 24-in diameter.

L. Additional valve actuator requirements are included with the individual valve types and as noted in Article 1.02 above.

M. Position indication and direction of opening arrows shall be embossed, stamped, engraved, etched, or raised castings. Decals or painted indications shall not be allowed.

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N. Unless otherwise noted, valves larger than 3-in nominal diameter shall be provided with position indicators at the point of operation.

2.03 VALVE ACTUATORS - POWERED

A. General:

1. Electric actuators for 1/4 turn valves three inches and under, which do not have submergence requirements, and which exhibit a maximum torque specified below shall be operated on 120 volt single phase power as specified below. Other actuators shall be operated on 480 volt power.

2. Actuators shall conform to AWWA C540, insofar as applicable and as herein specified. Actuators shall be O-ring sealed, watertight to standard NEMA 4X/6, submersion to 6 feet for 30 minutes. Actuators installed in vaults below grade and elsewhere subject to submergence shall be watertight to standard NEMA 6P/IP68, 15 ft for 72 hours minimum. Actuators installed in hazardous locations as noted on the Electrical Drawings and/or area classification sheets of the Architectural Drawings shall be FM certified explosion proof for Class 1 Division 1 & 2, Groups C & D and also meet the standard NEMA 4X/6 rating.

3. Valve service/operation shall be as indicated on the P&IDs and as specified in the Process Control Descriptions in Section 13305.

4. 480 Volt powered actuators shall be Rotork IQ/IQM; Limitorque MX; EIM TEK 2000; AUMA SA/SAR. Actuators shall be configured as required to provide for part turn or multi-turn and be coupled with gearboxes as required to obtain the speed and operating torque as required for the valve or gate it controls.

5. Modulating actuators shall contain proportional control unit and be capable of 1200 starts per hour, open-closed valve actuators shall not require a proportional control unit, and be capable of 60 starts per hour.

6. Where shown on Instrumentation Drawings, actuators shall have a digital control module, to allow valves or gates to be positioned remotely via a 2-wire non-proprietary field bus protocol. Digital control module shall be equipped with serial communication ports to allow actuation to be linked by a two wire local area network utilizing Modbus function code (report by exception) and arranged in a self-healing ring configuration, with multi-drop taps to each actuator.

B. 120 Volt Single Phase Reversing, Non Spring Return Electric Actuators for 1/4 Turn Valves, 100 to 1000 in-lb Torque Range

1. Valve actuators shall be sized by valve supplier meeting requirements of AWWA C540. Actuators shall be mounted on valves in valve supplier's facility, and factory tested.

2. Actuators shall operate on 120 volt, 60 hz single phase, power supply. Enclosure rating shall be NEMA 4X, constructed of cast aluminum or steel alloy, powder coated or fusion bonded epoxy finish.

3. Power train shall be self-locking planetary epicyclical gear design, consisting of hardened steel and or hardened bronze alloy gears with bronze bearings. Housing penetrations shall

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be sealed with mechanical seals. Housing shall be equipped with space heaters. Valve mounting system shall be ISO 5211.

4. Actuator shall be designed for open/close/jog reversing service. Proportional/modulating service shall be provided where required in the equipment specifications or Instrumentation Drawings. Actuators shall have visual mechanical indication of position. Manual override shall be direct worm drive with minimum 5 inch diameter hand wheel. Hand wheel size shall be provided such that a maximum 40 lb rim pull is required.

5. Motors shall be designed specifically for valve actuation service, with Class F insulation, with split phase capacitor protection. Duty cycle shall not be less than 40% at 100 degrees F. for open/close duty, and 100% for modulating duty. 90 degree travel time shall vary from 10 to 20 seconds depending on actuator size. Actuators shall have SPDT contacts for remote valve position indication.

6. Actuators shall be P Series as manufactured by Promation Engineering, Brooksville, FL, or equal.

C. 480 Volt Powered Actuators for Part Turn or Multi-Turn Valve Operation:

1. Operation:
   a. Capabilities shall be provided to position valve (or gate) locally via Local/Off/Remote selector switch and Open/Stop/Close push buttons.
   b. For on/off service, when in remote, actuator shall accept one remote signal to open valve or gate and a second remote signal to close valve or gate.
   c. For modulating service, when in remote actuator shall accept a 4-20mADC position control signal, and shall position valve 0-90 degrees or gate 0-100% of travel in proportion to control signal.
   d. Unless stated otherwise in valve specifications, actuator and gearing size shall be designed to operate valve at a disc speed of one foot travel per minute of operation. For quarter turn valves, valves shall rotate from stop to stop in 30 seconds per foot of throat diameter.

2. Functional:
   a. Motor operated valve controller shall include motor, operator unit gearing, limit switch gearing, limit switches, control power transformer, position transmitter (when required), torque switches, bored and key-wayed drive sleeve for non-rising stem valves, declutch lever and auxiliary handwheel as a self-contained unit. Valve contacts shall be capable of handling the current equivalent of a NEMA 1 size starter.
   b. Reversing starters shall be integral with actuator, and shall be solid-state starters for modulating service. Electro-mechanical reversing starters shall be acceptable for open-close service and shall be mechanically and electrically interlocked.
   c. Limit switches and gearing shall be an integral part of valve control. Limit switch gearing shall be made of bronze or stainless steel and shall be fully lubricated, intermittent type and totally enclosed to prevent dirt and foreign matter from entering gear train. Limit switches shall be of adjustable type capable of being adjusted to trip at any point between fully opened valve and fully closed valve. Limit and torque switches shall be provided for stopping valve in both directions. Mid-travel switches shall be provided as required. Set position shall not be lost if over travel occurs in either manual or electric modes of operation.

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d. Valve position transmitter shall be a gear actuated, two-wire device, producing 4-20 mADC signal proportional to 0-90 degree valve position or to 0-100% of valve travel. Transmitter shall be provided with easily accessible zero and span adjustment potentiometers. Valve actuator shall be provided with a local digital or mechanical indicator integral with operator with a 0-100 percent scale. DC power supply shall be provided integral with operator and powered from 110 volt AC internal transformer. Positioner board shall provide repeatable accuracy to 0.25% of span. There shall be separate trim pots on positioner board for zero, span and dead band adjustment.
e. Speed of actuator shall be responsibility of system supplier with regards to hydraulic requirements and response compatibility with other components within control loop. Each valve controller shall be provided with a minimum of two limit switch functions, one for opening and one for closing. Each limit switch will have two normally open and two normally closed contacts. Gear limit switches shall be geared to driving mechanism and in step at all times whether in motor or manual operation. Provision shall be made for two extra sets of limit switches as described above, each to have two normally open and two normally closed contacts. Each valve controller shall be equipped with a double torque switch. Torque switch shall be adjustable and responsive to load encountered in either direction of travel. Limit and torque switch contacts shall be silver inlay type.
f. Each actuator shall include monitor relays to remotely indicate fault signal for indication of power failure, phase failure, thermal switch tripped, torque switch tripped between travel stops and Local-Off-Remote selector switch position.

3. Physical:
   a. Operator shall be equipped with open-stop-close push-buttons, a local-off-remote selector switch and indicating lights mounted on operator. Where operator will not be situated between 2-ft-0-in and 7-ft-0-in above operator platform, and where shown on Drawings provide a separate remote valve operating station.
   b. Motor shall operate on 460 volt, 60 hertz, 3 phase power and shall be sized by actuator manufacturer to provide the required output torque for service intended. Motor shall have Class F insulation, with a duty rating of at least 15 minutes at 40 degrees C ambient temperature. Motor shall be specifically designed and built by actuator manufacturer for electric actuator service. Commercially available motors shall not be acceptable. Actuator shall include a device to ensure that motor runs with correct rotation for required direction of valve travel regardless of connection sequence of the power supply.
   c. Operators utilizing multiple reduction power gearing shall consist of spur, helical, or bevel gearing and worm of hardened alloy steel, and the worm gear shall be alloy bronze. Operators utilizing single-stage reduction shall be single-stage worm gear totally enclosed in a fully lubricated gearcase, with filling and drain plugs. Non-metallic, aluminum, or cast gearing shall not be allowed. Output shaft shall incorporate thrust bearings of the ball or roller type at the base of the actuator.
   d. An operating wheel shall be provided for manual and/or emergency operation, engaged when motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. Operating wheel drive shall be mechanically independent of motor drive, and any gearing shall be such as to permit emergency manual operation, using a 40 pound force in a reasonable time. Clockwise operation of handwheel shall give closing movement of valve unless otherwise stated.

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e. Each actuator shall be supplied with a start-up kit including installation instructions, wiring diagrams, and spare cover screws and seals to provide for losses during commissioning.
f. Continuous mechanical dial indication of valve and position shall be provided. Mechanical dial position indicator shall be in step with actuator at all times in both hand wheel and motor operation. For modulating applications, mechanical dial position indicator shall include graduations of 0-100 percent scale.

4. Wiring and Terminals:
   a. Internal wiring shall be of tropical grade PVC insulated stranded cable of 5 amp minimum rating for control circuits and of appropriate size for the motor 3 phase power. Each wire shall be clearly identified at each end.
   b. Terminals shall be of stud type embedded in a terminal block of high tracking-resistance compound. The 3-phase power terminals shall be shrouded from control terminals by means of an insulating cover.
   c. Terminal compartment shall be separated from inner electrical components of actuator by means of a watertight seal. Terminal compartment of actuator shall be provided with three threaded cable entries.
   d. Each actuator shall be provided with a commissioning kit consisting of a wiring diagram and installation and operation manual. A separate wiring diagram shall be provided inside the terminal cover. No special tools, devices or parts shall be required for commissioning.
   e. Actuators shall have separately sealed motor and control compartments. Operators shall have space heaters in their limit switch, motor, and control compartments.

5. Remote Control Stations:
   a. Where shown on Drawings, or where specified in Equipment Specifications, valve actuators shall be furnished with control stations suitable for mounting remotely from, but, in vicinity of actuator. Remote mount control station shall include a Local - Off - Remote selector switch, Open - Stop - Close pushbuttons and Open - Close indicating lights. Control station operators shall be heavy duty devices mounted in a cast iron, cast aluminum, or stainless steel NEMA 4X enclosure suitable for wall mounting. Wire gauge and device quality shall meet or exceed the requirements of Division 16. Local - Off - Remote selector switch shall have auxiliary contacts for remote indication of switch position. Local - Off - Remote selector switch shall have provisions for padlocking in the "Off" position. Additional functionality and/or devices to those specified above are detailed on Instrumentation P&IDs and/or Electrical Control Schematic drawings. Refer to Drawings for confirmation of scope of the Remote Control Stations.

6. Performance Test:
   a. Each actuator shall be shop performance tested, and individual test certificates shall be supplied without additional charge to Owner. Test certificates shall be submitted prior to shipment of valve actuators. Test equipment shall simulate a typical valve load, and the following parameters shall be recorded:
      1) No load current.
      2) Current at maximum torque setting.
      3) Stall current.
      4) Torque at maximum torque setting.
      5) Stall torque.

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6) Test voltage and frequency.
7) Flash test voltage.
8) Actuator output speed.

D. VALVE ACTUATORS – Hydraulic Cylinder Operator:

1. Cylinders: Hydraulic Cylinder Operators for rubber seated pump discharge control valves shall move valve to any position from full open to full closed where a minimum pressure of 50 PSI is applied to cylinder. Wetted parts of cylinder shall be corrosion resistant and cylinder rods shall be corrosion resistant stainless steel. Rod seals shall be of non-adjustable wear compensating type. Cylinder actuators shall be Pratt MDT Type with Dura-Cyl Cylinder. Four limit switches shall be provided on cylinder operator.

2. Control System: Pump discharge valve cylinder operators shall be controlled by the Pratt pump, check surge control system hydraulic control panel. Control panel and cylinder operator shall have adjustable opening and closing speeds from 60 to 300 seconds, and an adjustable emergency closure speed of 10 to 30 seconds.

2.04 VALVES

A. Butterfly Valves (Metal Body – except Energy Efficient Process Duty Butterfly Valves) – **Tag Type: BFV1**

1. Butterfly valves and actuators for low pressure air piping shall conform to the AWWA C504, except as specified herein. Valves shall have a minimum 150 psi pressure rating and be equal to those manufactured by Henry Pratt; M&H or DeZurik valve companies.

2. Butterfly valves shall be flanged end with face to face dimensions in accordance with Table 3 of above mentioned AWWA standards for short-body valve, or wafer type.

3. Valve seats shall be full resilient seats retained in the body or on the disc edge in accordance with Section 4 of the above mentioned AWWA standards. If the resilient seat is in the body, the disc shall be of cast ni-resist conforming to ASTM A436 Type 1 with the periphery machined to a smooth spherical surface. If the resilient seat is mounted on the disc edge it shall be held in place by a one-piece Type 304 stainless steel retaining ring and stainless Nylock screws, the disc shall be of ASTM A48, Class 40 cast iron and a mating Type 304 stainless steel ring shall be installed in the valve body. Resilient seats shall be Hycar or equal for water service and Nordel or equal for air service. Resilient seats in valves for air service shall be mounted in the body only.

4. The valve body shall be constructed of close grain cast iron per ASTM A126, Class B with integrally cast hubs for shaft bearing housings of the through boss-type. Permanently self-lubricating body bushings shall be provided and shall be sized to withstand bearing loads. Stuffing box of liberal dimensions shall be provided at the actuator end of the vane shaft, arranged so that the packing can be replaced by removing the bronze follower without removing the actuator. Packing shall be of the Chevron type as manufactured by Garlock Packing Company. A sealing element utilizing O-rings shall also be acceptable.

5. The valve shaft shall be of Type 304 stainless steel and designed for both torsional and shearing stresses when the valve is operated under its greatest dynamic or seating torque.

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6. In general, the butterfly valve actuators shall conform to the requirements of Section 4.2.8 of AWWA C504, insofar as applicable and as specified herein.

7. Gearing for the actuators where required shall be totally enclosed in a gear case in accordance with Section 4.2.8.6.9 of AWWA C504 standard.

8. The manual actuators shall conform to Section 4.2.8.6 of AWWA C504 standard, insofar as applicable. Valves shall have handwheel or lever actuators and open left, or counterclockwise. Actuators shall have indicators to show position of the valve disc. Actuators shall be rigidly attached to the valve body.

B. Energy Efficient Process Duty Butterfly Valves – **Tag Type: BFV2**

1. Valves shall be high flow, concentric disc, bi-directional seal, hard backed cartridge seat, wafer style, except for dead end service, where fully lugged valves shall be used. Valves shall be 50 PSI pressure rated for low pressure air service, 150 PSI rated for fluid service. Air service valves shall be fitted with trim capable of continuous 250 degree F. service, intermittent 300 degree F. service.

2. Body shall be one piece cast iron for wafer style, ductile iron for lug style. Body class shall be ASME 150.

3. Disc shall be undercut type if employed for air service, material shall be ASTM B148 C854, 958 or 995 aluminum bronze or CF8M stainless steel. Valve discs shall employ a positive machined drive utilizing a rectangular drive connection, or shall be attached using Type 416 stainless steel taper pins or bolts with locking nuts.

4. Valves shall have dry stem journals with no leakage to stems at rated pressure. Stem packing shall not be required. Valves shall be constructed with separate upper and lower stems or single through stems. Separate stems shall be positively retained by tangential pins. Stems shall be 17-4 PH or Type 416 stainless steel. Through stem design shall be supported by a minimum of two upper bearings and one lower bearing.

5. Seats shall be hard backed cartridge type consisting of a resilient EPDM liner molded to a rigid non-metallic backing ring. Viton liners shall be utilized for high temperature or corrosive duty service. Valve seats shall be field replaceable with hand tools.

6. The upper stem shall be guided by two self-lubricating bronze or PTFE bearings. The lower stem for single piece stem designs shall be guided by one self-lubricating bronze or PTFE bearing.

7. Valves shall be Crane Centerline Series 200; Apollo Series 141: Demco NE-C (2” to 12”), or NF-C (14” to 24”), manufactured by Cameron Valves & Measurement, or equal.

C. Gate Valves – **Tag Type: GV**

1. Gate valves 2-1/2-in in diameter and smaller in size, shall have flanged, screwed, or solder ends as required; and shall be bronze, solid wedge, rising-stem-type gate valves such as Fig. 47 and 48 by Jenkins Bros. or equal products by Crane; Fairbanks or Kennedy Valve Mfg. Co.

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2. Gate valves 3-in and larger in size, unless otherwise specified or approved, shall be iron body, bronze mounted, solid wedge gate valves with flanged ends and conforming to the AWWA C500, insofar as applicable and in addition to the following requirements:
   a. Valves shall be outside screw and yoke type with rising stem.
   b. Face to face dimension shall conform to USA Standard Face to Face and End to End Dimensions of Ferrous Valves, (USAS B16.10) for 125 lb cast-iron valves.
   c. Bronze gate rings shall be fitted into grooves of dovetail or similar shape in the gates. For grooves or other shapes, the rings shall be firmly attached to the gates with bronze rivets.
   d. Handwheels shall turn counterclockwise to open the valves. Handwheels shall be of ample size and shall have an arrow and the word OPEN cast thereon to indicate the direction of opening.
   e. Stuffing box follower bolts shall be of steel and the nuts shall be of bronze.
   f. The design of the valves shall permit packing the valves without undue leakage while they are wide open and in service.
   g. O-ring stuffing boxes may be used.

D. Plug Valves – **Tag Type: PV**

1. Plug valves shall be of the offset disc type 1/4 turn, non-lubricated, serviceable (repacked) under full line pressure and capable of sealing in both directions at the rated pressure. The disc shall be completely out of the flow path when open. Valves 4-in to 20-in shall have a minimum port area of 80 percent and valves 24-in and larger shall have a minimum port area of 70 percent when measured by the percent cross sectional area of equivalent size Schedule 40 steel pipe. Plug valves shall be as manufactured by Dresser Industries; Homestead; DeZurik or equal.

2. Valves shall be rated at 175 psi W.O.G. (Water, Oil, Gas) working pressure (minimum) for sizes 4-in to 12-in inclusive, and at 150 psi W.O.G. (Water, Oil, Gas) working pressure (minimum) for sizes 14-in and larger. At the above rated minimum working pressures, the valves shall be certified by the manufacturer as permitting zero leakage for a period of at least 1/2 hour with pressure applied in either direction. At the direction of the Engineer, the valve manufacturer may be requested to perform a valve seat leakage test, witnessed by the Engineer to prove compliance with this Section.

3. Valve bodies shall be of cast iron, 30,000 psi tensile strength, ASTM A126, Class B and of the top entry, bolted bonnet design, cast with integral flanges conforming to ANSI B16.1 Class 125 dimensions. All exposed bolts, nuts, and washers shall be zinc or cadmium plated, except for buried or submerged valves, which shall have Type 304 stainless steel hardware.

4. The valve disc shall be ductile iron, ASTM A536, Grade 65-45-12. The disc shall be removable without removing the valve from the line. The disc shall have an integral upper and lower shaft which shall have seals on the upper and lower journals to prevent entrance of solids into the journals. Shaft bearings, if provided, shall be stainless steel at both upper and lower stem journals. The operator shaft shall have easily replaceable seals which shall not require adjustment.

5. The valve seating surface shall provide full 360 degree seating by contact of a resilient seating material on the disc mating with welded-in high nickel content overlay or a thermo-setting epoxy seating surface in the body. The seating design shall be resilient and of the

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continuous interface type having consistent opening and closing torques and shall be non-jamming in the closed position. If the thermosetting epoxy seat is provided, then the resilient seating surface on the disc shall be of Buna-N, either applied to the entire disc, or a ring clamped to the disc by an 18-8 stainless steel clamp ring with self locking 18-8 stainless steel screws. The seat ring shall be replaceable without removing the valve from the line.

6. At a minimum, discs shall have a resilient facing of neoprene. If the entire valve body interior and disc is lined, they shall be coated with a corrosion resistant coating of either thermo-setting resin or PVC and Buna-N, as specified below.
   a. For thermo-setting resin coated internals, all interior surfaces of valve body, including the journals and seating surface shall be coated with thermoplastic nylon of a fusion bonded, minimum water adsorption type. The valve disc and bearings surfaces shall be coated with a heat catalyzed thermoset epoxy. Prior to coating, all surfaces shall be sandblasted to white metal in accordance with SSPC SP-5. Coatings shall be tested electrically in accordance with ASTM G8 and prove to be less than one circle diameter inch disbondment.
   b. For plastic lined valves, the valve body shall be completely PVC coated except for the seating surface which shall be epoxy coated. The valve disc shall be Buna-N coated. Disc shaft bearings shall be heavy duty, self-lubricated, Type 304 stainless steel.

7. All valves 8-in and larger shall be equipped with handwheel actuators. Handwheel actuators shall be of the geared or travelling nut type. All actuators shall have enclosed and sealed housings to allow the reduction mechanism to operate in a lubricant. Seals shall be provided on all shafts to prevent the entry of dirt and water into the housing. All shaft bearings shall be furnished with permanently lubricated bronze bearing bushings. Actuator shall clearly indicate valve position and an adjustable stop shall be provided. Construction of actuator housing shall be semi-steel. Hardware on actuators shall be of the same materials as the valves.

8. Each valve 6-in and smaller shall be provided with its own latch lock lever. Provide adjustable limit stops for both opening and closing and a clearly marked position indicator.

9. Where shown on the Drawings, air operated valves shall be equipped with single acting, spring return to close on loss of air pressure, pneumatic cylinder operators for on-off control. Air pressure of 50 to 100 psi will be supplied to the valve. Cylinder operators shall be rack and gear type. Gearing shall be sealed in a semi-steel housing, and run in a lubricant. The operator shall clearly indicate valve position. An adjustable stop shall be provided to set closing torque. Provision shall be made for manual operation of the valve through a 2-in square nut for operation by a wrench. Maximum valve shut-off pressure shall be 25 psi. Valve shall be required to seal reverse pressures of not more than 25 psi. Furnish one 3-way solenoid valve for each air operated valve. The solenoid valve shall be furnished separate from the air operated valve for remote mounting in the field. The solenoid valve shall operate the actuator to close the valve when deenergized. The solenoid shall operate on 120 Volt, single phase, 60 Hz power supply and shall be provided with manual override. Solenoid valve shall otherwise be as specified herein.

10. Where required on the Drawings, submerged plug valves shall be provided with extended operating nut as shown on the Drawings. The assemblies shall be furnished complete with

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all stem guides and adapters required for a complete installation. Extended nut shall be suitable for use with a Tee handle wrench as previously specified herein.

11. Where required on the Drawings, provide extended stem, floor stand, and handwheel for valves mounted below a slab. Provide position indicator and an arrow to show direction of rotation to open the valve.

12. Where required on the Drawings, furnish position indicating switches on valves. Switches shall be single pole, double throw, at either limit of open or close, or both limits as shown. Switches shall be enclosed in a NEMA 4 enclosure, and contacts shall be rated 10 Amps at 120 VAC.

13. All plug valves shall be installed so that the direction of flow through the valve is in accordance with the manufacturer's recommendations.

14. Plug valves for yard piping shall be as specified above for interior plug valves, except valves shall have mechanical joint ends and stainless steel hardware. Buried actuators shall be as specified above and shall be for buried, submerged service with seals on all covers and shafts and all exposed hardware of stainless steel. Provide valve box, stem extension and operating nut as specified above for gate valves.

E. Ball Valves – **Tag Type: BV**

1. Ball valves for plant water piping shall be air actuated, bronze, resilient seated, regular port, threaded two piece bolted body type valves. The body and cap shall be of brass, ASTM B30, the ball and stem of Type 316 stainless steel, and the seats and seals of TFE. The valves shall have full floating ball and shall be non-lubricated. Valve seats shall be easily accessible and replaceable. Valves shall be rated to 250 psi and shall be as manufactured by Jamesbury; WKM, or equal.
   a. Valve actuators shall be spring return, diaphragm, pneumatic type, air to open, designed for operation of quarter turn valves. Actuators shall operate on an air supply of 50 to 100 psi. Valve pressure differential will be up to 60 psi. The actuator drive train shall be completely enclosed in a weather tight enclosure, designed for outdoor installation. Valve port position shall be indicated.

F. Check Valves (except Rubber Flapper Swing Check Valves) – **Tag Type: CV**

1. Check valves for cast iron and ductile iron pipelines shall be swing type and shall meet the material requirements of AWWA C508. The valves shall be iron body, bronze mounted, single disc, 150 psi working water pressure, non-shock and hydrostatically tested at 300 psi. Ends shall be 125 lb ANSI B16.1 flanges.
   a. When there is no flow through the line the disc shall hang lightly against its seat in practically a vertical position. When open, the disc shall swing clear of the waterway.
   b. Check valves shall have bronze seat and body rings, extended bronze hinge pins and bronze nuts on the bolts of bolted covers.
   c. Valves shall be so constructed that disc and body seat may easily be removed and replaced without removing the valve from the line. Valves shall be fitted with an extended hinge arm with outside lever and spring. Springs with various tensions shall be provided and springs approved by the Engineer shall be installed.

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2. Check valves 2-in and smaller for installation in copper and steel pipes shall be bronze, swing type, 125 lb WSP with solder or screwed ends.

G. Rubber Flapper Swing Check Valves – **Tag Type: SCV**

1. The Rubber Flapper Swing Check Valve shall have a heavily constructed ductile iron or ductile iron body and cover. The body shall be long pattern design (not wafer) with integrally cast-on end flanges. The flapper shall be Buna-N having an "O" ring seating edge and be internally reinforced with steel.

2. Flapper shall be captured between the body and the body cover in a manner to permit the flapper to flex from closed to full open position during flow through the valve. Flapper shall be easily removed without need to remove valve from line. Check Valves shall have full pipe size flow area. Seating surface shall be on a 45 degree angle requiring the flapper to travel only 35 degrees from closed to full open position, for minimum head loss and non-slam closure.

3. Buna-N Flapper (hi-strength coated fabric - coated both sides with 70 Duro) which creates an elastic spring effect, molded internally, to assist the flapper to close against a slight head to prevent slamming.

4. Valve shall be designed for 250 psi working pressure for wastewater.

5. Valve exterior and interior shall be Fusion Bonded Epoxy coated, 8 mils minimum for high resistance to corrosion.

6. A mechanical indicator shall be provided to provide disc position indication on valves 3-inch and larger. The indicator shall have continuous contact with the disc under all operating conditions to assure accurate disc position indication.

7. An inductive type proximity switch shall be furnished mounted to the mechanical indicator with its target mounted to the indicator rod or on the valve body with its target mounted internally on the flapper to transmit an electrical signal that the flapper is open or closed.

8. The Valve Manufacturer shall have been regularly engaged in the design and manufacture of Rubber Flapper Swing Check Valves for at least five years and shall submit a list of at least five separate installations in service for a minimum of five years for engineer approval prior to release to manufacture.

9. Materials of construction shall be certified in writing to conform to ASTM specifications as follows:

a.	Body & Cover	ASTM A536 Grade 65-45-12 Ductile Iron
b.	Rubber Flapper	Buna-N

10. Valve shall be APCO Series 100 Rubber Flapper Swing Check Valve, as manufactured by Valve & Primer Corporation, Schaumburg, Illinois, U.S.A.; Val-Matic 500 Series or approved equal.

H. Knife Gate Valves – **Tag Type: KGV**

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1. Knife gate valves shall be of the full bonnet type with full face to face flanged connections. Raised face flanges shall be drilled to ANSI 125/150 lb standard. Valves shall be rated for 150 psi certified working pressure.

2. Valves shall be metal to metal seated and shall have full port straight through openings. Valve bodies including knife gate and accessories shall be furnished with all wetted parts of Type 316 stainless steel.

3. Valve packing shall consist of multiple layers of asbestos-free Teflon. Valves shall be marked for direction of flow and shall have a round bottom with a beveled knife-edge. All sides of the gate shall be finish ground. Stems shall be stainless steel. Yoke sleeves shall be bronze. Valve bodies shall incorporate guides and jams to assist the seating. Valves shall have raised face seats with a relieved area around the seat to prevent jamming.

4. Valves 14-inch and larger shall be equipped with bevel gear actuators. Electric motor operators shall be provided as noted on the drawings otherwise valves shall be manually operated and provided with handwheel or chainwheel operator, as noted.

5. Valves shall be Tyco Rovalve Figure 220, Dezurik (Hilton Valve, Inc.) figure H-200, or approved equal.

6. Shop drawing submittals shall include a listing of at least five installations of similar size and service for the valves specified above.

I. Combination Air & Vacuum Relief Valves – **Tag Type: CAV**

1. All pipeline air and vacuum valves shall be supplied with shutoff gate or ball valves with operator handle or lever removed. Valves shall be properly vented and piped to drain.

2. Valve pressure rating shall be at least equal to the attached pipe's rating.

3. Valves for sewage service shall have connections for draining and flushing with isolation ball valves for connection size up to 3 inch, and solid wedge gate valves for size 4 inch and larger.

4. Valves shall be designed to release large amounts of air during pipeline filling, release small amounts of air accumulated during pipeline operation, and allow large volume of air during pipeline drainage or pipe break. Combination double orifice air/vacuum valve for general service in sizes 1 to 6 inches housed in a tubular stainless steel body with epoxy powder coated cast iron or steel ends secured by means of stainless steel tie rods. Valve shall have an intake orifice area equal to the nominal size of the valve.

5. Air release/vacuum valves shall be compact single cylindrical chamber design with multiple solid cylindrical HDPE control floats. Discharge of pressurized air shall be controlled by the seating and unseating of a small orifice nozzle on a natural rubber seal affixed into the control float. The nozzle shall have a flat seating land surrounding the orifice so that damage to the rubber seal is prevented. Venting of large quantities of air during pipeline filling shall be accomplished through the large orifice at the top of the valve. Large orifice sealing shall be affected by the flat face of the control float seating against an "O" ring housed in a dovetail groove circumferentially surrounding the orifice. The valve shall feature integral 'Anti-Shock' Orifice mechanism in the top float which

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shall operate automatically to limit transient pressure rise or shock induced by closure to twice the valves rated working pressure. Vacuum relief shall be accomplished through the large orifice when the control floats fall due to negative pressure in the pipeline. The valve design shall incorporate an over pressure safety feature that will fail without an explosive effect, such as is normally the case when highly compressed air is released suddenly. The feature shall consist of easily replaceable gaskets.

6. Valves shall be rated for 230 psi service. Materials of construction shall be as follows: barrel- Type 304L stainless steel; top and bottom flanges- fusion bonded epoxy steel; upper/lower floats and anti-shock orifice- UHMW PE; small orifice nozzle seat and o-rings- Buna-N; nozzle, baffle plate, tie rods, studs, nuts, washers- Type 304 stainless steel. End Connections shall be NPT up to 2 inch, 125 lb flange 3 to 6 inch.

7. Valves shall be as manufactured by Vent-O-Mat, Model RBX 2521 or 1631.

J. Pinch Valves – **Tag Type: PNV**

1. Pinch valves shall be furnished with an open 125 psi ANSI flanged cast iron body. The closing mechanism shall be designed so that the upper and lower pinch bars move at the same time as the handwheel is turned. The sleeve shall be natural rubber and shall close to form a leak-proof seal. The inside diameter of the sleeve shall be equal to the inside diameter of the pipe. The pinch valve shall be Series 70 as manufactured by Red Valve Co.; Flex-Valve by General Rubber Corporation; or equal, and handwheel or chainwheel operated.

K. Globe Valves – **Tag Type: GLV**

1. Valves for copper plant air and water lines shall have threaded or solder ends, bronze body, renewable composition disc, 300 lb cold water non-shock working pressure, Jenkins Fig. 106A or 1200. Valves shall open left or counterclockwise. As far as possible, all globe valves shall be from one manufacturer. Valves shall be mounted as indicated on the Drawings or as directed by the Engineer.

L. Needle Valves – **Tag Type: NV**

1. The needle valves shall have a cast bronze body and be constructed in accordance with ASTM B62 and shall be designed for an operating pressure of 125 psi and a 200 psi maximum test pressure. Ends shall be ANSI B2.1 threaded. The valves shall have a rising bronze stem and non-slip malleable iron hand wheel.

2. The needle valves shall be Figure 680 by the Wm. Powell Company, Cincinnati, OH, or Figure 88 by Crane Company, Valve Division, Chicago, IL, or equal.

M. Pressure Regulating Valves – **Tag Type: PRV**

1. Pressure regulating valves shall be installed on the plant water lines as shown on the Drawings.

2. Valves 3-in and larger shall be flanged with globe body, fully bronze mounted, external pilot operated, single seat with seat base equal to size of valve and shall be similar by Golden-Anderson Water Pressure Reducing Valve, Figure 45D by the Golden-Anderson

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Company, Pittsburg, PA; Clayton Model 90 by Cla-Val Company, Newport Beach, CA, Model 40 WR by Ross Valve Mfg. Company Inc., Troy, NY or equal.

3. The valve shall be packed with leather or some other approved material to ensure tight closure and prevent metal to metal friction and sticking. The valve shall be furnished with indicator rod, to show position of opening of the piston, and pet cocks for attachment to valve body for receiving gauges for testing purposes.
   a. The pilot valve, controlling operation of main valve, shall be easily accessible and so arranged to allow for its removal from the main valve, while the main valve is under pressure. The pilot valve shall be easily adjustable without removal of the springs, weights or use of special tools. The control piping on the valves shall have strainers to prevent plugging of control mechanisms.

4. The design shall be such that repairs and dismantling internally of main valve may be made without its removal from the line.

5. The flanges shall be ANSI 125 lb. The valve body shall be constructed of cast iron.

6. The valve shall maintain pre-adjusted downstream pressure for varying rates of flow through the positioning of the piston by the pilot without causing water hammer and without causing waste of water, and without cavitation.

7. Prior to shipment of the valves the manufacturer shall factory test the valves under the pressure and flow conditions specified above. The manufacturer shall furnish the Engineer with certified copies of the factory test results.

8. Pressure regulating valves 2-in and smaller shall be installed where indicated on the Drawings. Valves shall be rated 150 psig working pressure, with bronze or brass body; renewable stainless steel seat and flexible diaphragm of suitable material. Outlet pressure shall be easily field adjustable over the pressure ranges tabulated below.

9. Strainers for installation upstream of pressure regulating valves are specified in this Section. The pressure regulating valve manufacturer shall specify the screen mesh or size of perforations that are required to protect the regulating valve.

10. Pressure regulating valves 2-in and smaller shall be designed for the following criteria:

System		No.	Max	Pressure (psig)
Flow (gpm)	Upstream	Downstream		

11. Pressure regulating valves 2-in and smaller shall be Series EP or Series T by Ross Valve Manufacturing Co., Inc.; Model 43D by Golden Anderson Company; Series H-1300 by Mueller Co.; or equal.

12. All pressure regulating valves shall have flanged connections, or shall have unions mounted in the pipe on each side of the valve.

N. Solenoid Valves – **Tag Type: SV**

1. Solenoid valves shall be packless piston type direct acting, 2-way or 3-way, valves and shall be ASCO Valve Red Hat by Automatic Switch Co.; Atkomatic Valve Co., or equal for air and water service.

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2. Valves on water seal lines to stuffing boxes and for flushing water shall be of the normally open type. All other valves shall be of the normally closed type.

3. Valves shall have forged brass bodies, NPT end connections of the size shown on the Drawings, 300 or 400 series stainless steel internal parts, and Buna N or Ethylene Propylene valve seats. Valves shall have a 150 psig (minimum) safe working pressure and zero minimum operating pressure differential. Connections to be threaded.

4. Except as otherwise specified herein, valves shall have NEMA 4 solenoid enclosures, shall be suitable for operation on a 120 Volt, single phase, 60 Hz power supply and shall be provided with a continuous duty Class F coil and a manual operator.

5. Valves located in hazardous areas, as noted on the Drawings, shall be furnished with explosion proof enclosures suitable for Class I, Division I, Group D locations.

O. Thermoplastic Valves – **Tag Type As Noted Below**

1. General:
   a. Valves shall be certified as completely compatible with intended and specified service; compatibility shall apply to material of valve and internal components, including seals, gaskets, O-rings and washers; solvents and primers used in valve joint make-up shall be specifically in conformance with written instructions of valve supplier. Service chemicals and service conditions are shown in the piping sections in Division 15.
   b. Except as otherwise specified, valve ends shall be socket-type designed for solvent welding. Solvent and primer shall be as specified in piping specifications, except that valves installed in systems carrying strong oxidizing, high alkalinity, and strong acid solutions shall contain NO fumed silica, and shall be Weld-On 724 for CPVC pipe as manufactured by IPS Corp., Compton, CA and Oatey Industrial Grade Low VOC Heavy Duty Gray for PVC pipe as manufactured by Oatey Corp., Cleveland OH.
   c. Valve body material shall be same as piping system in which valve will be installed, unless explicitly stated otherwise on Drawings or in valve specification.
      1) PVC shall have a cell classification 12454 according to ASTM D 1784, made from unplasticized polymer, and generally suitable for service to 120 degrees F.
      2) CPVC shall have a cell classification 23447 according to ASTM D 1784, generally suitable for service to 180 degrees F.
      3) Polypropylene (PP) shall conform to material requirements of ASTM D 4101 for copolymer polypropylene.
      4) PVDF (polyvinylidene fluoride) shall be manufactured from high molecular weight polymers of vinylidene fluoride.
      5) Manufacturer of valves shall retain material source quality documentation and shall furnish it to Engineer upon request.
   d. Unless otherwise specified:
      1) Valve seats shall be Teflon, or Teflon encapsulated elastomer. Alternative materials shall not be substituted without complete documentation provided to Engineer of service suitability.
      2) Flange Gaskets shall be low torque, full face ANSI B16.5 with two concentric convex rings between ID and bolt hole diameter, constructed of EPDM, PTFE-bonded EPDM or PVDF-bonded EPDM as manufactured by Asahi/America or

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equal. Documentation shall be provided to show compatibility of bonded surface material for fluid service intended.

3) Valve external hardware shall be Type 316 stainless steel. No internal metallic components shall be exposed to service fluid.
4) No factory or field coatings shall be applied to valves.

e. Valves, except butterfly valves, shall have a non-shock service pressure rating of not less than 120 psig at 70 degrees F.
f. Valves from 1/2-in"-2-in shall have a snap-on fit handle attaching to valve stem to prevent handle from falling off. Valves from 2-1/2-in to 6-in shall have a handle mechanically attached to valve stem to prevent handle from falling off. Valves shall have limit stops at full open and full close to limit handle rotation.
g. Valves shall be given hydrostatic and pressure and leakage tests at factory. Provide certified copy of test results.
h. Valves shall be the standard, catalogued products of the following manufacturers:
1) Chemtrol.
2) Asahi/America.
3) Plast-O-Matic.
4) George-Fischer.
5) IPEX.
i. Valves specified as furnished with equipment or equipment systems shall comply with these requirements.

2. Ball Valves: Tag Type Noted Below.
a. Ball valves shall be double-union type, unless otherwise specified, full-port, adjustable seats.
b. Provide quarter-turn manual valve operator unless mechanized actuators are specified on Drawings.
c. **Tag Type TBV1**- General Service. Shall be PVC body, furnished with socket ends, EPDM O-rings and stem seals, PTFE seats with EPDM O-ring backup.
d. **Tag Type TBV2-** Sodium Hypochlorite Service. Shall be PVC body, furnished with socket ends, Viton B O-rings and stem seals, PTFE seats with Viton B O-ring backup. Sodium hypochlorite service ball valves shall have ball drilled to permit venting of pressure and gas from confined ball cavity, when valve is closed. Drilling shall vent to vented portion of piping in which valve is installed. Drilling shall be 1/8-in opening, de-burred and drilled by factory only. Directional indicator arrow labels shall be provided on valve body to indicate flow/vent.

3. Butterfly Valves - **Tag Type: TBFV.**
a. Valves shall be of lined body design with PP disc with only the liner, seals and disc as wetted parts. Liner shall be molded and formed around body, functioning as a gasket on each side of valve. Double O-ring seals on top and bottom disc trunnions will fully isolate a Type 316 stainless steel straight-through stem. Body and disc shall be [PVC, PP, PVDF], Liner (seat) shall be [EPDM, FKM, NBR], o-rings shall be [EPDM, FKM, NBR].
b. Valves shall be wafer style, and lug style for dead-end service as applicable.
c. Each valve shall be furnished with a lever actuator on sizes through 6-in; gear operator on sizes 8-in and larger.
d. Butterfly valves shall be Type 57 as manufactured by Asahi/America, FK Series as manufactured by IPEX or equal.

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4. Diaphragm valves - **Tag Type: TDV.**
   a. Valves shall have double-union ends. Acid service valves shall have flanged ends.
   b. Acid service body and bonnet shall be PVDF, ASTM D3222 Cell Classification Type II.
   c. Diaphragms shall be single layer EPDM or Viton as the service requires or shall be two layer, non-laminated. Acid service diaphragms shall be non-laminated, layered EPDM, PVDF gas barrier, PTFE wetted.
   d. Valve shall have a full-width weir, designed for throttling, and complete bubble-tight closure.
   e. Provide a handwheel valve operator, with a stainless steel stem, a cast stem sleeve and a clear plastic stem cover with a position indicator; provide an adjustable limit stop to prevent over-travel.
   f. Diaphragm valves shall be Type 14 as manufactured by Asahi/America, VM Series as manufactured by IPEX or equal.

5. Gate Valves – **Tag Type: TGV.**
   a. Gate valves shall be non-rising stem, polypropylene plugs and viton seals. Where indicated on Drawings, valves shall be provided with stem extensions and handwheels, as manufactured by Asahi/America or equal.

6. Needle Valves – **Tag Type: TNV.**
   a. Needle valves shall be designed for close control of flow throttling with a multi-turn valve handle. Valves shall have FPM seal, PTFE seat. Stem shall be 20 or 24 pitch for fine throttling control. Valve shall have lugs or panel screw on bonnet for panel mounting.
   b. Needle valves shall be as manufactured by Chemline Plastics Limited, George Fischer, or equal.

7. Ball Check Valves – **Tag Type: TBCV.**
   a. Ball check valves shall be double-union style with socket ends, solid and completely spherical ball, EPDM seals, PTFE seat, capable of either horizontal or vertical mounting. Ball check valves shall be SXE Series as manufactured by IPEX or equal.

8. Diaphragm Check Valves – **Tag Type: TDCV.**
   a. Diaphragm check valves shall be union PVC, CPVC or PVDF body, thread or socket weld ends, EPDM or FKM diaphragms. Acid service valves shall be PVDF body with FKM diaphragm, and shall be furnished with PVDF flanges to connect to flanged piping. Valves shall be mountable in any position, and shall be Plast-O-Matic model CKM or equal.

9. Swing Check Valves – **Tag Type: TSCV.**
   a. Swing check valves shall be flanged body; seats and seals shall be EPDM, FKM or PTFE as required by fluid service; disc serviceable from top entry without removing valve, o-ring sealed top flange, ANSI flanged ends. Outside lever and weight and limit switch mounting shall be provided where shown on Drawings. Swing check valves shall be SC Series as manufactured by IPEX or equal.

10. Backpressure Regulating/Control Valves – **Tag Type: TBPV.**
    a. Backpressure control valves shall be spring-loaded diaphragm design, fully-adjustable pressure setting, set to assure continuous positive pressure at the pump discharge.
    b. Furnish with reinforced Teflon diaphragms and elastomer-coated springs.

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c. Body shall be of same material as pipeline in which it is installed or, CPVC if not otherwise specified. Valves shall be manufactured by Plast-O-Matic, or equal.

11. Pressure Relief Valves – **Tag Type: TPRV.**
    a. Relief valves shall be spring opposed, angle-pattern design, with adjustable relief pressure and locking nut. Pressure shall be adjustable over range up to 100 psig.
    b. Valve spring shall be elastomer-coated and isolated from the process flow. Elastomer shall be compatible with fluid service. Diaphragm shall be reinforced Teflon.
    c. Relief valves shall be piped as indicated, and if not indicated, relief piping shall be directed to floor or adjacent gutter or drain.
    d. Pressure relief valve settings shall be set to a pressure as recommended by pump or equipment supplier and adjusted at time of equipment testing, inspection and start-up.
    e. Body shall be of same material as pipeline in which it is installed or, CPVC if not otherwise specified. Valves shall be equal to Model RVD by Plast-O-Matic; Type A by Asahi/America or equal.

P. Fire Hydrants

1. Fire hydrants shall be the Eddy Type Clow Corp. Fig. F-2640 "Break Flange" and shall conform to the "Standard Specification for Fire Hydrants for Ordinary Water Works Service", AWWA C502, and shall in addition meet the specific requirements and exceptions which follows:

2. Hydrants shall be according to manufacturer's standard pattern and of standard size and shall have one 4-1/2-in steamer nozzle and two 2-1/2-in hose nozzles.

3. Hydrant inlet connections shall have mechanical joints for 6-in ductile-iron pipe, or 6-in asbestos cement pipe.

4. Hydrant valve opening shall have an area at least equal to that area of a 5-1/4-in minimum diameter circle and be obstructed only by the valve rod. Each hydrant shall be able to deliver 500 gallons minimum through its two 2-1/2-in hose nozzles when opened together with a loss of not more than 2 psi in the hydrant.

5. Each hydrant shall be designed for installation in a trench that will provide 5-ft minimum cover. Hydrant extensions shall be as manufactured by the company furnishing the hydrants and of a style appropriate for the hydrants as furnished.

6. Hydrants shall be hydrostatically tested as specified in AWWA C502.

7. All nozzle threads shall be National (American) Standard.

8. Hydrant operating nut shall be AWWA Standard pentagonal type measuring 1-1/2-in point to flat.

9. Hydrants shall be equipped with O-ring packing.

10. Each nozzle cap shall be provided with a Buna N rubber washer.

11. Hydrants shall be so arranged that the direction of outlets may be turned 90 degrees without interference with the drip mechanism obstructing the discharge from any outlet.

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12. A bronze or rustproof steel nut and check nut shall be provided to hold the main hydrant valve on its stem.

13. Hydrants must open by turning operating nut to right (clockwise) and must be marked with an arrow and word "open" to indicate the direction to turn stem to open hydrant.

14. All iron work to be set below ground, after being thoroughly cleaned, shall be painted with two coats of asphalt varnish specified in AWWA C502 and iron work to be left above ground shall be shop painted with two coats of paint of quality and color to correspond to the present standard of the Owner.

15. Each hydrant shall be designed such that the hydrant valve closes with line pressure preventing loss of water and consequent flooding in the event of traffic damage.

16. Each hydrant shall be furnished with a steel chain holder, double steel hose cap chain, steel steamer cap chain and any other hooks and/or appurtenances required for proper use.

Q. Yard Hydrants

1. Yard hydrants shall be 2-1/8-in Valve Post Type A-24059 by Mueller Company, Decatur, IL or equal. Yard hydrants shall have two 1-1/2-in hose nozzles and 3-in mechanical joint inlet connections, except hydrants on the deck of the aeration tanks shall have flanged connections. Operating nuts shall be standard AWWA 2-in square and caps shall have attachment chains. Two operating wrenches (Type A-24089) of suitable size shall be furnished to operate all yard hydrants. Each hydrant shall have one of the two 1-1/2-in hose nozzles fitted with a special adapter fittings to reduce the nozzle to 3/4-in male hose connections.

R. Hose End Valves – **Tag Type: HEV**

1. Hose end valves for installation on the plant water lines shall be Fig. No. 074 by Fairbanks; Fig No. 112 by Jenkins or equal. Furnish cap and chain.

S. Flap Valves – **Tag Type: FV**

1. Flap valves to be used in the underdrain system discharge lines for pressure relief shall be 4-in and shall be flanged end, Clow Figure F-1494 for walls and F-1492 for floors.

T. Mud Valves – **Tag Type: MV**

1. Mud valves for the mechanical bar screen channels shall be flanged, cast iron body, bronze mounted, non-rising stem. Provide stem extension and upper stem support. The stem extension shall be designed for operation by a standard 2-in square wrench. The upper stem support shall be supported from the channel walls, not the grating. Mud valves shall be Clow Fig. F-3075; Mueller, or equal.

2.05 SURFACE PREPARATION AND SHOP PRIME PAINTING

A. Not withstanding any of these specified requirements, coatings and lubricants in contact with potable water shall be certified as acceptable for use with that fluid.

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B. If not specified herein, coatings shall comply with the requirements of Section 09901 and 09902. In case of a conflict, requirements of this Section govern.

C. If manufacturer's requirement is not to require finished coating on interior surfaces, then manufacturer shall so state and no interior finish coating will be required, if acceptable to Engineer.

D. Exterior surface of various parts of valves, operators, floor-stands and miscellaneous piping shall be thoroughly cleaned of all scale, dirt, grease or other foreign matter and thereafter one shop coat of an approved rust-inhibitive primer such as Inertol Primer No. 621 shall be applied in accordance with instructions of paint manufacturer or other primer compatible with finish coat provided.

E. Unless otherwise noted, interior ferrous surfaces of valves shall be given a shop finish of an asphalt varnish conforming to AWWA C509, (except mounting faces/surfaces) or epoxy conforming to AWWA C550 with a minimum thickness of 6 mils.

F. Ferrous surfaces obviously not to be painted shall be given a shop coat of grease or other suitable rust-resistant coating. Mounting surfaces shall be especially coated with a rust preventative.

G. Special care shall be taken to protect uncoated items and plastic items, especially from environmental damage.

2.06 FACTORY INSPECTION AND TESTING

A. Factory inspection, testing and correction of deficiencies shall be done in accordance with the referenced standards and as noted herein.

B. See Division 1 for additional requirements. Also refer to PART 1, especially for required submission of test data to Engineer.

C. In addition to tests required by referenced standards, the following shall also be factory tested:

1. Pressure regulating valves shall be factory tested at specified pressures and flows.

2. Butterfly valves shall be factory tested to demonstrate drop tight closure at specified conditions.

3. All types of air and vacuum valves.

PART 3 EXECUTION

3.01 INSTALLATION

A. Valves and appurtenances shall be installed per manufacturer's instructions in locations shown, true to alignment and rigidly supported. Damage to above items shall be repaired to satisfaction of Engineer before they are installed.

B. Install brackets, extension rods, guides, various types of operators and appurtenances as shown on Drawings, or otherwise required. Before setting these items, check Drawings and figures

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which have a direct bearing on their location. Contractor shall be responsible for proper location of valves and appurtenances during construction of the work.

C. Materials shall be carefully inspected for defects in construction and materials. Debris and foreign material shall be cleaned out of openings, etc. Valve flange covers shall remain in place until connected piping is in place. Operating mechanisms shall be operated to check their proper functioning and nuts and bolts checked for tightness. Valves and other equipment which do not operate easily, or are otherwise defective, shall be repaired or replaced at no additional cost to Owner.

D. Where installation is covered by a referenced standard, installation shall be in accordance with that standard, except as herein modified, and Contractor shall certify such. Also note additional requirements in other parts of this Section.

E. Unless otherwise noted, joints for valves and appurtenances shall be made up utilizing same procedures as specified under applicable type connecting pipe joint and valves and other items shall be installed in proper position as recommended by manufacturer. Contractor shall be responsible for verifying manufacturers' torqueing requirements for all valves.

3.02 INSTALLATION OF MANUAL OPERATIONAL DEVICES

A. Unless otherwise noted, operational devices shall be installed with units of factory, as shown on Drawings or as acceptable to Engineer to allow accessibility to operate and maintain item and to prevent interference with other piping, valves, and appurtenances.

B. For manually operated valves 3-in in diameter and smaller, valve operators and indicators shall be rotated to display toward normal operation locations.

C. Floor boxes, valve boxes, extension stems and low floor stands shall be installed vertically centered over operating nut, with couplings as required and elevation of box top shall be adjusted to conform to elevation of finished floor surface or grade at completion of Contract. Boxes and stem guides shall be adequately supported during concrete placement to maintain vertical alignment.

3.03 INSPECTION, TESTING AND CORRECTION OF DEFICIENCIES

A. See also Division 1. Take care not to over pressure valves or appurtenances during pipe testing. If unit proves to be defective, it shall be replaced or repaired to satisfaction of Engineer.

B. Functional Test: Prior to plant startup, items shall be inspected for proper alignment, quiet operation, proper connection and satisfactory performance. After installation, manual valves shall be opened and closed in presence of Engineer to show valve operates smoothly from full open to full close and without leakage. Valves equipped with electric, pneumatic or hydraulic actuators shall by cycled five times from full open to full closed in presence of Engineer without vibration, jamming, leakage, or overheating. Pressure control and pressure relief valves shall be operated in presence of Engineer to show they perform their specified function at some time prior to placing piping system in operation and as agreed during construction coordination meetings

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C. Various pipe lines in which valves and appurtenances are to be installed are specified to be field tested. During these tests any defective valve or appurtenance shall be adjusted, removed, and replaced, or otherwise made acceptable to Engineer.

D. Various regulating valves, strainers, or other appurtenances shall be tested to demonstrate their conformance with specified operational capabilities and deficiencies shall be corrected or device replaced or otherwise made acceptable to Engineer.

3.04 CLEANING

A. Items including valve interiors shall be inspected before line closure, for presence of debris. At option of Engineer, internal inspection of valve and appurtenances may be required any time that likelihood of debris is a possibility. Pipes and valves shall be cleaned prior to installation, testing disinfection and final acceptance.

3.05 DISINFECTION

A. Disinfection of valves and appurtenances on potable water lines and where otherwise noted, shall be as specified in Section 01445.

END OF SECTION

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SECTION 15120
PIPING SPECIALTIES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install complete test, and make ready for operation all piping specialties required by the work of this Contract. Specific piping materials, systems and related installation and testing requirements shall be coordinated with the related sections in Divisions 2, 13 and 15. The items shall include the following:

1. Unions
2. Flanged Joints
3. Plugs and Caps
4. Miscellaneous Adaptors
5. Vents and Drains
6. Shock Absorbers (Water Hammer Arrestor)
7. Line Strainers
8. Service Clamps
9. Cleanouts
10. Floor Drains
11. Quick Connect Couplings
12. Mechanical Sleeve Seals
13. Flexible Connectors
    a. Sleeve Couplings
    b. Split or Grooved Couplings
    c. Flange Adapters
    d. Pump and Equipment Flexible Connectors
    e. Flexible Connectors
14. Expansion Joints
    a. Single- and Multiple-Arch Type
    b. Bellows Style
    c. Flexible Metal Hose
15. Harnessing and Restraints
16. Diaphragm Seals for Gauges

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17. Thermometers
18. Rotameters and Flow Indicators
19. Propeller Flow Meters
20. Ball Sight Flow Meters
21. Vane Sight Flow Meters
22. Batch Meters
23. Turbine Flow Meters
24. Static Mixers
25. Pipe Cleaning Equipment
26. Spray Nozzle
27. Chemical Diffusers
28. Diffuser Sockets
29. Appurtenances and Miscellaneous Items

1.02 RELATED WORK

A. Piping penetrations are included in Section 01172.

B. Pipe testing, cleaning and disinfection is included in Section 01445.

C. Pipeline color coding and labeling is included in Section 09902.

D. Piping materials and systems are included in other Sections of Division 15.

E. Specialties and apparatus furnished with equipment and systems are included in individual Sections in Divisions 11 and 13.

F. Valves and appurtenances are included in Section 15100.

G. Pipe hangers and supports are included in Section 15140.

H. Thermal insulation is included in Section 15250.

I. Electric heat tracing is included in Section 15257.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01300, general submittals for piping, piping systems and pipeline appurtenances are listed below. It is not intended that all submittals listed below be

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provided for all piping materials and systems. Refer to individual System or Piping Sections for specific submittals.

B. Shop Drawings and Product Data

1. Piping layouts with specialties.

2. Location of pipe hangers and supports.

3. Location and type of backup block or device to prevent joint separation.

4. Large scale details of wall penetrations and fabricated fittings.

5. Catalog cuts of specialties, joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.

6. Catalog cuts of all pipeline appurtenances specified herein.

7. Brochures and technical data on coatings and linings and proposed method for application and repair.

C. Samples

D. Design Data

E. Test Reports

1. Four copies of certified shop tests showing compliance with appropriate standard.

2. Four copies of all field test reports, signed by Contractor.

F. Certificates

1. Copies of certification for all welders performing work in accordance with ANSI B31.1.

G. Manufacturers Installation (or application) instructions.

H. Statement of Qualifications

I. Manufacturers Field Reports

J. Project Record Documents in accordance with Section 01720.

K. Operation and Maintenance Data in accordance with Section 01730.

L. Warranties in accordance with Section 01740.

1.04 REFERENCE STANDARDS

A. ASTM International

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1. ASTM A36 - Standard Specification for Carbon Structural Steel.

2. ASTM A126 - Standard Specification for Gray Iron Casting for Valves, Flanges and Pipe Fittings.

3. ASTM A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.

4. ASTM A278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 Degrees F.

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

6. ASTM A325 - Standard Specification for Strength Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

7. ASTM A536 - Standard Specification for Ductile Iron Castings

8. ASTM A575 - Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.

9. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

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

B. American National Standards Institute (ANSI)

1. ANSI A13.1 - Scheme for the Identification of Piping Systems.

2. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form)

3. ANSI B18.2 - Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws.

4. ANSI B31 - Code for Pressure Piping.

5. ANSI B31.1 - Power Piping

C. American Society of Mechanical Engineers (ASME)

1. ASME B2.1 - Specifications, Dimensions, Gauging for Taper and Straight Pipe Threads (except dry seals).

2. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.

3. ASME B16.5 - Pipe Flanges and Flange Fittings

D. American Welding Society (AWS)

1. AWS B3.0 - Welding Procedure and Performance Qualifications

E. American Water Works Association (AWWA)

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1. AWWA C110 - Ductile-Iron and Gray-Iron Fittings, 3-in Through 48-in (75mm Through 1200mm), for Water and Other Liquids.

2. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

3. AWWA C219 - Bolted Sleeve-Type Couplings for Plain-End Pipe

4. AWWA C606 - Grooved and Shouldered Joints.

5. AWWA Manual M11 - Steel Pipe - A Guide for Design and Installation.

F. Plumbing and Drainage Institute (PDI)

1. WH 201 - Water Hammer Arrestors

G. Underwriters Laboratories (UL)

H. Factory Mutual (FM)

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 materials shall be new and unused.

B. Install piping to meet requirements of local codes.

C. Provide manufacturer's certification that materials meet or exceed minimum requirements as specified.

D. Coordinate dimensions and drilling of flanges with flanges for valves, pumps and other equipment to be installed in piping systems. Bolt holes in flanges to straddle vertical centerline.

E. Reject materials contaminated with gasoline, lubricating oil, liquid or gaseous fuel, aromatic compounds, paint solvent, paint thinner and acid solder.

F. Pipe-joint compound, for pipe carrying flammable or toxic gas, must bear approval of UL or FM.

G. Unless otherwise specified, pressures referred to in all Piping Sections are expressed in pounds per square inch, gauge above atmospheric pressure, psig and all temperature are expressed in degrees Fahrenheit (F).

1.06 DELIVERY, STORAGE AND HANDLING

A. During loading, transportation and unloading, take care to prevent damage to pipes and coating. Carefully load and unload each pipe under control at all times. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to ensure no injury to pipe and lining. Cover or cap all pipe ends while pipe is in storage, until it is made a part of the work.

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PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Specific piping materials and appurtenances are specified in the respective Piping or System Sections. The use of a manufacturer's name and/or model number is for the purpose of establishing the standard of quality and general configuration desired.

B. Equipment shall be of the size shown on the Drawings or as noted and as far as possible equipment of the same type shall be identical and from one manufacturer.

C. Equipment shall have the name of the maker, nominal size, flow directional arrows (if applicable), working pressure for which they are designed and standard referenced specifications cast in raised letters or indelibly marked upon some appropriate part of the body.

D. Unless otherwise noted, items shall have a minimum working pressure of 150 psi or be of the same working pressure as the pipe they connect to, whichever is higher and suitable for the pressures noted where they are installed.

2.02 UNIONS

A. Unions shall be brass or bronze unions for joining nonferrous pipe; malleable brass or bronze-seated iron or steel unions for joining ferrous pipe; PVC unions for joining PVC pipe; CPVC unions for joining CPVC pipe.

2.03 FLANGED JOINTS

A. Flanged Joints. Bolts and nuts, Type 304 stainless steel, bolt number and size same as flange standard; studs - same quality as machine bolts; 1/16-in thick rubber gaskets, compatible with the fluid service, with cloth insertions; rust-resistant coatings.

2.04 PLUGS AND CAPS

A. Provide standard plug or cap as required for testing; plugs and caps shall be suitable for permanent service.

B. Plug, cap or otherwise cover all piping work in progress.

2.05 MISCELLANEOUS ADAPTORS

A. Between different types of pipe and/or fittings special adapters may be required to provide proper connection. Some of these may be indicated on the Drawings or specified with individual types of pipe or equipment. However, it is the Contractor's responsibility to ensure proper connection between various types of pipe, to structures and between pipe and valves, gates, fittings and other appurtenances. Provide all adapters as required, whether specifically noted or not.

B. As required, these adapters shall be suitable for direct bury, with proper dielectric insulation and as a minimum, if metallic (not stainless steel or galvanized), with two coats of Coal Tar Epoxy.

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2.06 VENTS AND DRAINS

A. 1/2-in vents shall be provided at the high point in each system. Vent connections may be tapped, provided the tap will accept three full threads on the bronze nipple.

B. 1-1/2-in drains shall be provided to permit drainage of each system located on the invert of the blind flange; provide hose-end valve.

2.07 SHOCK ABSORBERS (WATER HAMMER ARRESTORS)

A. Shock absorbers shall be supplied on the nonpotable (protected) and potable water piping. The shock absorbers shall be Model 1485-1 as manufactured by Josam Manufacturing Company, Michigan City, IN; similar model by J.R. Smith or Zurn Industries.

B. Arrestors shall be sized in accordance with PDI WH 201, for all hot and cold water systems.

C. Placement shall be in accordance with PDI WH 201 with a minimum of one shock absorber at each quick acting valve, lever operated valve, self closing valve and self closing valve/faucet; or a minimum of one for each battery of these fixtures. The water hammer arrestors shall be accessible for maintenance.

2.08 LINE STRAINERS

A. "Y" Type Strainers

1. Manual strainers furnished for pipe diameters smaller than 2-in shall be "Y" type, capable of removing solids 0.01-in in diameter and larger. The strainer body shall be of semi-steel construction for steel pipe and brass or bronze for copper pipe and shall conform to the latest revision of ASTM A278, Class 30. Strainer elements, including woven wire mesh, shall be constructed of stainless steel.

2. The design of the strainer body shall be such that the cleanout plug and screen may be easily removed to permit inspection and cleaning without disassembly of the inlet and outlet piping. End connections shall be ANSI screwed pipe threads.

3. Sufficient spare screen shall be furnished for replacement of all "Y" type units at least once. The strainers shall be designed for a maximum operating pressure of 150 psig. They shall be as manufactured by GA Industries Inc., Cranberry Township, PA or equal.

B. Manual Basket Strainer

1. Manual basket strainers shall be furnished for pipe diameters 2-in in diameter and larger, as shown on the Drawings. The strainer body shall be of cast iron construction. The strainer elements, including woven wire screen, shall be constructed of Type 304 stainless steel. The design of the basket strainer body shall be such that the bolted lid and basket may be easily removed for inspection and cleaning without disassembly of the inlet and outlet piping.

2. A trap with a blow-off port shall be provided for removing any material that may settle at the bottom. The strainers shall be designed for a maximum operating pressure of 150 psig,

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and shall be 74-DS as manufactured by GA Industries Inc., Cranberry Township, PA or equal.

3. Proper blowoff piping with valve shall be supplied and run to nearest drain.

2.09 SERVICE CLAMPS

A. Service clamps for outlet sizes up to 2-in shall have malleable or ductile iron bodies which extend at least 160 degrees around the circumference of the pipe and shall have neoprene gaskets cemented to the saddle body. Bodies shall be tapped for IPS. Clamps shall be of the double strap design. Service clamps shall be Style 91 by Dresser Industries, Inc.; Smith Blair; Mueller or equal.

B. Service clamps for outlet sizes 4-in through 12-in where the outlet size is not greater than half the size of the main pipe shall have ductile iron bodies and a neoprene circular cross section O-ring gasket confined within the body. Outlet shall be AWWA C110 flange or AWWA C111 mechanical joint as required for the application. Straps shall be alloy steel, minimum 1/4-in by 1-1/2-in in cross section and fabricated with 3/4-in threaded ends. Service clamps shall be Fig. A-10920 or A-30920 by American Cast Iron Pipe Company or equal.

2.10 CLEANOUTS

A. Interior flush floor cleanouts shall consist of a coated cast iron ferrule, a tapered threaded bronze cleanout plug, adjustable housing and a scoriated round cast iron tractor cover with bronze top. Interior flush floor cleanouts shall be Type No. 56056 by Josam Manufacturing Co., Michigan City, IN, similar models by Tyler, or equal.

B. Exterior cleanouts shall consist of a coated cast iron ferrule with cut-off sections, a tapered threaded bronze cleanout plug, Josam 58486 or equal, with a heavy round coated cast iron access frame with anchor flanges and a gasketed cover, Josam Type No. 58680, similar models by Tyler or equal. Exterior cleanouts shall be installed as noted on the Drawings.

C. Cleanouts shall be located where shown on the Drawings.

D. Cleanout connections to 6-in cast iron bell and spigot soil pipe and cleanout connections to 6-in ductile iron bell and spigot pipe shall be caulked.

2.11 FLOOR DRAINS

A. Floor drains shall have 8-in square, adjustable, bronze top strainers and coated cast iron bodies.

B. Floor drains shall have outlet connections for 4-in cast iron bell and spigot soil pipe except where required by other type pipe and/or indicated on the Drawings. They shall be Series No. 30004-8S by Josam, similar by Tyler or equal.

2.12 QUICK CONNECT COUPLINGS

A. Couplings shall be of the cam and groove type consisting of a male adapter conforming to MIL-C-27487. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leakproof under pressures up to

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100 psig. Each adapter shall be furnished with a dust cap complete with a 18-in long security chain of corrosion resistant material. Couplings shall be by Civacon, a Division of OPW; Ever-Tite Coupling Products, a Division of APG; or equal. Units shall be "drip proof," providing totally dry connections and disconnections.

B. Adapters shall be furnished in accordance with the Drawings, or as required by the installation.

C. Materials of construction shall be compatible with the fluid service.

2.13 MECHANICAL SLEEVE SEALS

A. Mechanical sleeve seals shall be used to secure and seal the annular space around all new sleeved and core-drilled wall penetrations.

B. A single seal shall be provided for all sleeve and cores in walls up to 14-in thick; dual sleeves shall be provided in larger walls.

C. Galvanized steel wall sleeves and concrete core diameter shall be sized sufficiently larger to accommodate the modular elements, per the manufacturer's recommendations.

D. Bolts and hardware shall be carbon steel, zinc-plated. Pressure plates shall be corrosion-resistant acetal resin.

E. Mechanical sleeve seals shall consist of modular bolted, synthetic rubber sealing elements, Link-Seal by Thunderline Corp. or equal.

F. Refer to Section 01172 for additional requirements.

2.14 FLEXIBLE CONNECTORS

A. Sleeve Couplings

1. Provide plain end type ends to be joined by sleeve couplings as stipulated in AWWA C219.
   a. Join welds on ends by couplings without pipe stops. Grind flush to permit slipping coupling in at least one direction to clear pipe joint.
   b. Outside diameter and out-of-round tolerances shall be within limits specified by coupling manufacturer.
   c. Provide lugs in accordance with ASTM A36.
   d. Provide hardened steel washers in accordance with ASTM A325.
   e. Plastic plugs shall be fitted in coupling to protect bolt holes.
   f. Nuts and bolts
      1) Provide bolts and bolt-studs in accordance with ASTM A307 and ANSI B1.1 with hexagonal or square heads, coarse thread fit, threaded full length with ends chamfered or rounded.
      2) Project ends 1/4-in beyond surface of nuts.
      3) Hexagonal nuts with dimensions in accordance with ANSI B18.2 and coarse threads in accordance with ANSI B1.1.

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2. Middle ring of each mechanical coupling shall have a thickness at least equal to that specified for size of pipe on which coupling is to be used and shall not be less than 10-in long for pipe 30-in and larger and not less than 7-in long for pipe under 30-in in diameter.
   a. Omit pipe stop from inner surface of middle rings of couplings whenever necessary to permit removal of valves, flowmeters and other installed equipment.
   b. Provide pipe stops in other couplings.

3. Clean and shop prime with manufacturer's standard rust inhibitive primer.

4. Furnish gaskets of a composition suitable for exposure to the fluid service.

5. Where shown on the Drawings, anchor sleeve-coupled joints with harness bolts. Weld harness lugs to steel pipe.
   a. Joint harness bolts shall be of sufficient length, with harness lugs placed so that coupling can be slipped at least in one direction to clear joint. Provide harnesses of sufficient number and strength to withstand test pressure as recommended in AWWA M-11.
   b. Each harness shall have a minimum of two 5/8-in diameter bolts.

6. Unless otherwise specified with the individual type of pipe, sleeve couplings (mechanical couplings) shall be Victaulic Style 230/230S (formerly Depend-O-Lok ExE unrestrained) or Victaulic Style 232/232S (formerly Depend-O-Lok FxF self-restrained); ITT (formerly Smith Blair) Style 411; Dresser Style 38, similar models by Baker or equal, with the pipe stop removed.

7. Similar insulation type couplings shall be provided at the face of buildings, between different type metals or where otherwise noted.

8. In addition to those locations noted on the Drawings, sleeve couplings shall be provided on all piping where it connects with a structure or buried directly under a structure at the structure's expansion joints. Special treatment will be required where pipe is encased in concrete, utilizing minimum 3-in thick styrofoam placed perpendicular to the horizontal centerline of the coupling.

B. Split or Grooved Couplings

1. Split couplings shall be cast in two or more parts. When secured together with ASTM A183 bolts and nuts, couplings shall engage grooved or shouldered pipe ends and encase an elastomeric gasket to create a pipe seal. Gasket material shall be as recommended by the manufacturer for the service required.

2. Split couplings shall be as manufactured by Victaulic Company of America or equal. Numbers below refer to Victaulic Co. items, for reference only.

3. Unless otherwise specified with the individual type of pipe:
   a. Flexible split ring couplings shall be:
      1) grooved ends - Style 77 (for steel/stainless steel) or Style 31 (for grooved ductile iron)
      2) shouldered ends – Victaulic Style 44 or Fluid Master
      3) fixed ends – Victaulic Style 232/232S (formerly Depend-O-Lok FxF)

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b. Rigid split ring couplings shall be:
   1) grooved ends - rigid groove with Style 31 couplings on ductile iron 36-in and smaller diameter with sufficient wall thickness per AWWA C606, or manufacturer's recommendation, or standard groove with Style 07 Zero-Flex coupling on manufactured steel or IPS pipe.
   2) shouldered ends – Style 44 coupling on ductile iron over 36-in diameter or without sufficient wall thickness per AWWA C606 or on manufactured steel pipe or thin wall stainless steel pipe. Field welding of shoulders of ductile iron pipe is specifically prohibited.

4. Ductile iron pipe for use with split-type coupling joints shall have radius grooved ends conforming to AWWA C606. Pipe shall have grooved ends to provide either a rigid joint or flexible joint as shown on the Drawings and as specified herein. Flexible joint grooving shall permit expansion and contraction, and angular deflection. Rigid joint grooving shall allow no angular or linear movement. Minimum pipe wall thickness for grooved pipe shall be the following class:

Size	Class
4 thru 16	53
18	54
20	55
24	56

5. Grooved couplings for steel and stainless steel piping shall have roll grooving, machine-grooving, or ring collars fully welded to the pipe or fitting.

6. Rigid split couplings may be substituted for flanges as noted on the Drawings and in the individual pipe requirements.

7. Certain minimum thickness of pipe walls are required by AWWA C606 and coupling manufacturers for use of various type split couplings with certain pipes. Utilize at least those minimum wall thicknesses required (unless a greater thickness is specified or required in the individual pipe specifications) with split couplings.

8. If minimum thicknesses are not utilized with grooving, then a shouldered end treatment with couplings as noted shall be utilized.

C. Flanged Adaptors

1. Flanged adaptor connections for grooved or shouldered end pipe compatible with split couplings at fittings, valves and equipment shall be VIC-Flange Style 341 (ductile iron pipe and VIC-Flange Style 741/743 (for steel and stainless steel pipe) by the Victaulic Company of America, equal by Depend-O-Lok F x F FAC by Victaulic Depend-O-Lok Inc or equal.

2. Flanged adaptor connections for plain end pipe at fittings, valves and equipment shall be Dresser Style 127 or 128, equal by ITT (formerly Smith-Blair); Depend-O-Lok F x E FAC by Victaulic Depend-O-Lok, Inc. or equal.

D. Pump and Equipment Flexible Connectors

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1. The flexible connectors shall be expansion/vibration joints of the single arch type of butyl rubber construction with carcass of high grade woven cotton or suitable synthetic fiber and individual solid steel ring reinforcement. Soft rubber fillers shall be integrally cured into the arches to provide a smooth flow path to prevent settling of material into the arch. Joints shall be constructed to pipeline size and to meet working pressures and corrosive conditions similar to the line where installed. Joints shall have full faced fabric reinforced butyl flanges integral with the body.

2. Split steel or ductile iron back-up rings shall be provided to ensure a good joint. Rings shall be designed for mating with ANSI Standard minimum 150 lb flanges. All joints shall be finish coated with Hypalon or equal paint.

3. Expansion/vibration joints shall be furnished with control (harness) units. Harness units shall consist of minimum two drilled plates, stretcher bolts, and rubber washers backed by metal washers. The stretcher bolts shall prevent over-elongation of the joint. Extra nuts shall be provided on the stretcher bolts on the inside of the plate to prevent overcompression. All nuts, bolts and plates shall be galvanized.

4. The manufacturer of the expansion joints shall be a member of the Rubber Expansion Joint Division of the Fluid Sealing Association. Expansion joints shall be Style 1025 filled arch by General Rubber Corp., South Hackensack, NJ; or similar products of Mercer Rubber; Goodall Rubber; Garloc; Red Valve Co., Inc.; Proco Products Inc., Stockton, CA; or equal.

5. In addition to other locations shown on the Drawings, expansion joints shall be utilized in all exposed piping, within 1-ft of a building expansion joint, and on the suction and discharge side of all positive displacement pumps, compressors and rotating machinery, as close to the unit as possible.

E. Flexible Connectors

1. Provide one flexible connector for the seal water connection to each pump stuffing box. Connectors shall be of hose of Buna-N or similar resilient material, with fiber reinforcement, rated minimum 150 psi with bronze or Type 304 stainless steel NPT end fittings and shall be 12-in in length. Connectors shall be for the purpose of isolating pump vibration from the seal water piping.

2.15 EXPANSION JOINTS

A. Expansion Couplings

1. Bolted split sleeve type couplings to allow for thermal expansion and contraction at the pipe joints shall consist of one piece housing, gasket assembly, bolts and nuts, and end rings to hold the coupling in the proper location.

2. Couplings shall be manufactured from ASTM A240 Type 304 or Type 316 stainless steel material for use on stainless steel pipe. Couplings for use on carbon steel or ductile iron pipe shall be manufactured from ASTM A36 material. Gaskets shall be of a composition suitable for exposure to the fluid or air service.

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3. Carbon steel couplings shall be coated in accordance with liquid epoxy coating per AWWA C210 or fusion bonded epoxy coating per AWWA C213. Manufacturers standard shop primer will not be accepted as a coating system. Stainless steel couplings shall be passivated after all welding is completed.

4. End rings of the same material as the coupling housing shall be welded to the plain end of the pipe ends that form the joint per the coupling manufacturer's recommendations to hold the coupling in the proper location.

5. The expansion joints shall be designed for the axial movements shown on the Drawings along with the maximum axial force required to compress the joint. The joints shall prevent axial, lateral and rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 50 psig operating pressure unless otherwise indicated.

6. Expansion couplings for expansion joints for plain end pipe shall be Depend-O-Lok F x E by Victaulic Depend-O-Lok, equal by Red Valve Company, or equal.

B. Single- and Multiple-Arch Type

1. The expansion joints shall be of the rubber spool type, soft rubber filled with single-, double-, or triple-arch steel reinforced expansion joint, as indicated on the Drawings, suitable for 120 degrees F service, unless otherwise indicated.

2. The rubber used shall be suited for service with wastewater and/or wastewater sludge, including three-ply abrasion resistant liner.

3. Provide galvanized retaining rings to mate with adjacent pipe flanges.

4. The expansion joints shall be designed for the axial movements shown on the Drawings along with the maximum axial force required to compress the joint. The joints shall prevent axial, lateral and rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 50 psig operating pressure unless otherwise indicated.

5. Provide guides for each expansion joint.

C. Bellows Style

1. Expansion joints shall be hydraulically formed (with dies on the outside only) and having only longitudinal seam welds. These seams shall have the same strength, physical properties and thickness as the parent metal without grinding. Expansion joints, bellow, and internal sleeves shall be made of Type 304 stainless steel with carbon steel flanges at each end. The entire inside length of the expansion joint shall be straight. Manufacturer to provide lifting lugs at each flange for ease in handling and removal sheet metal coverage for any expansion joint.

2. Expansion joints shall be designed to prevent rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 25 psig operation pressure unless otherwise specified.

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3. Expansion joints shall be suitable for continuous operating temperature range of 200 to 300 degrees F.

4. Hinged or Gimbal expansion joints shall be used at horizontal and vertical bends in strict accordance with the standards of the EJMA, Inc.

5. Drilling and facing of flanges shall match or be suitable for use with equipment or companion flanges.

6. Guides shall be furnished with all bellows style expansion joints.

D. Manufacturer shall warrant this product to be suitable for the proposed conditions and shall furnish drawings for approval giving materials of construction, including gauge of corrugated element, maximum test pressure force to compress joint, bellows spring rate, shear force and end moment due to calculated traverse only. Manufacturer shall also furnish evidence of completing cycle life testing for the maximum diameter to be installed and shall indicate such assured cycle life test results on material submitted for approval.Flexible Metal Hose

1. Flexible metal hose shall be constructed of corrugated inner tubing of tin-bronze or Type 321 stainless steel and shall have an outer shield of wire-braid of either tin-bronze or Type 321 stainless steel.

2. The flexible hose connectors shall have a length not less than five times the nominal pipe diameter.

3. The connectors shall have 150 psi flanged ends in all sizes and shall be suitable for pressure up to 150 psig and temperatures to 400 degrees F.

4. Flexible hose connectors shall be manufactured by Flexonics; Metraflex or equal.

2.16 HARNESSING AND RESTRAINT

A. Where harnessed couplings or adapters are noted, they shall conform to AWWA Manual M11 except as modified by the Drawings or this Section.

B. Unless otherwise noted, size and material for tie rods, clamps, plates and hex nuts shall be as shown on the Drawings, or, if not shown on the Drawings, shall be as required in AWWA Manual M11. Manufactured restraining clamp assemblies shall be as manufactured by Star National Products (a division of Dresser Piping Specialties), Columbus, Ohio, or equal.

C. Restrained joints (such as welded, locking mechanical joints) shall be of the type specified with the individual type of pipe. If not specified, restrained (locking) mechanical joint pipe shall be of the manufacturer's standard design utilizing a locking device (ring or ears) integrally cast with the pipe.

D. For up through 18-in diameter ductile iron pipe only, the following may be used as an alternative to other restraint systems:

1. The optional mechanical joint restraints shall be incorporated in the design of a follower gland. The gland shall be manufactured of ductile iron conforming to ASTM A536.

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Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee-head bolts as specified with the pipe.

2. The restraint mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability. The gripping surfaces shall be wedges designed to spread the bearing surfaces on the pipe. Twist-off nuts, sized same as tee-head bolts, shall be used to ensure proper actuating of restraining devices. When the nut is sheared off, standard hex nut shall remain.

3. The mechanical joint restraint device for ductile iron pipe shall have a working pressure of at least 250 psi with a minimum safety factor of 2:1.

4. The mechanical joint restraint devices shall be of the type listed below or equal.

5. For Ductile Iron Pipe: EBAA Iron, Inc. Megalug 1100 series for up to 18-in only.

E. The Contractor shall be responsible for anchorage including restraint as noted elsewhere in Division 15.

2.17 PRESSURE GAUGES

A. Refer to Division 13 specifications.

2.18 DIAPHRAGM SEALS FOR GAUGES

A. Refer to Division 13 specifications.

2.19 THERMOMETERS

A. Thermometers shall be installed in the locations, and with the temperature ranges shown on the Drawings. Each thermometer shall be installed within a thermowell. The thermowell shall be designed to project sufficiently into the flow stream to assure an accurate thermometer reading. Thermowells shall be of Type 304 stainless steel, and shall have a bore suitable for a 1/4-in thermometer stem diameter. The process piping connection shall be 1/2-in NPT, except where flanged connections are shown.

B. Thermometers shall have a 3-in diameter dial case with bottom connection. The case, connection and stem shall be of Type 304 stainless steel and the lens shall be of tempered glass. Thermometers shall have an external calibration reset adjustment and shall be accurate to within one percent of scale.

C. Thermometers shall be as manufactured by Helicoid, a Division of Bristol-Babcock; Ashcroft, or equal.

2.20 ROTAMETERS AND FLOW INDICATORS

A. Rotameters shall be of the glass tube type with Borosilicate glass tubes, Type 302 stainless steel frames with slip-on covers, 10-in detached type aluminum scales graduated in gallons per minute, 10:1 flow range, accuracy of two percent of full scale and vertical screwed end connections. Capacity, size and materials of construction shall be in accordance with the

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following table. Tube size shall be the same size as the end connections. Pressure drop at rated capacity shall not exceed 32-in of water.

B. Flow indicators for shaft seal/flushing water systems shall be brass body, glass or plastic tube, stainless steel float, 125 psi pressure rating. Accuracy shall be at least five percent of full scale.

2.21 PROPELLER FLOW METERS

A. Propeller flow meters shall be of the magnetic drive type with no gears in the flow stream and no glands. They shall have plus or minus 1.5 percent accuracy over their entire range and plus or minus 0.5 percent repeatability.

B. The units shall be 150 psi rated, Series 100 by Sparling, similar by Badger or equal and shall have direct reading flow dial and non-resettable totalizer directly mounted on the unit, or extension, as noted. Meters shall be capable of being serviced and calibrated without removal from the line.

C. Propeller meters shall require no external electrical source for operation. Units including totalizer shall be suitable for buried and submerged outdoor service. Extension stems shall be furnished as required for the indicator shaft. Units shall be installed on a plain end spool piece, of the same outside diameter, pipe material and lining as the pipe they are connected to.

D. Fluid, capacity and pressure will be as noted on Drawings.

2.22 BALL SIGHT FLOW METERS

A. Ball sight flow meters (indicators) shall be vertically mounted, similar to rotameters, direct reading in gpm, with ball float, glass tube surrounded by clear exterior plastic, tube, stainless steel guide rods, PVC end fittings and shall be Type 20-1340 as manufactured by Schuttle and Koerting, a Division of Ametek or equal.

B. Units shall have 0 to 15 gpm capacity unless otherwise noted.

2.23 VANE SIGHT FLOW METERS

A. Meters shall be similar to ball sight flow meters, except utilizing an integral shunt and vane for reading of flow in gpm when mounted in the horizontal.

B. They shall be See-Flo by ERDCO (313-328-0550) or equal.

2.24 BATCH METERS

A. Batch meters shall be supplied complete by the manufacturer with controllers, flow control valves, transmitters, panels and any other required appurtenances to automatically dispense the preset quantity of water when activated. Proper interconnecting wiring, conduit and piping shall be the Contractor’s responsibility. Meters shall have one gallon gradations.

B. The batch meters and appurtenances shall be as supplied by Badger Meter or equal and shall operate on 120 Volt, single phase, 60 Hz power.

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2.25 TURBINE FLOW METERS

A. Turbine flow meters shall be of the magnetic drive type with no gears in the flow stream and no glands. They shall have plus or minus 1.5 percent accuracy over their entire range and plus or minus 0.5 percent repeatability.

B. The unit shall be by Badger or equal and shall have direct reading flow dial and non-resettable totalizer directly mounted on the unit. They shall be capable of servicing and calibrating without removal from the line and shall require no external electrical supply.

2.26 STATIC MIXERS

A. Static mixers shall be furnished and installed in the chemical lines at water dilution points at the locations shown on the Drawings. Mixers shall be single module type with six elements per module. Elements shall be of Type 316 stainless steel. Housing shall be of Schedule 10S, Type 316 stainless steel, with flanged or NPT threaded end connections. Units shall have a working pressure rating of not less than 100 psig.

B. Static mixers shall be Series 50 by Chemineer-Kenics or equal.

2.27 PIPE CLEANING EQUIPMENT

A. Pipe cleaning equipment shall consist of plastic projectiles (“pigs”) and projectile launching vessels (“pig” launchers) suitable for use in cleaning 8-in diameter pipelines.

B. “Pigs” shall be cylindrical, with a bullet shaped nose and concave base, covered with a criss-cross pattern of hard rubber strips. Material of construction shall be resilient polyurethane foam with a density of 5 lbs/cu ft. Furnish four “pigs”.

C. The “pig” launchers shall consist of adequately sized chambers to receive the “pigs”. One end of the chamber shall be provided with a reducer and flanged connection for attachment to the pipeline. The other end shall be provided with a hinged closure piece, using T-bolts for sealing and three 2-in diameter threaded connections fitted with isolation valves.

D. The “pig” launchers shall be of steel construction, suitable for 250 psi working pressure. The flange connection shall be flat face, matching ASME B16.1, 125 lb flanges.

E. Pipe cleaning equipment shall be as manufactured by Montauk Services, Inc. or equal.

F. A factory representative, who has complete knowledge of proper operation and maintenance shall be provided for one 8 hour day to instruct representatives of the Owner and Engineer on proper operation and maintenance, including startup and shutdown procedures, proper lubrication practices, if applicable, and troubleshooting of all equipment. If there are any difficulties with the training or in the operation of the equipment due to the manufacturer’s design, fabrication or installation, additional startup and training services shall be provided at no additional cost to the Owner.

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2.28 SPRAY NOZZLES

A. Nozzles shall be of the size, with feed rates as noted on the Drawings. Nozzles shall be attached to the distribution header, as indicated on the Drawings, via split-eyelet connections. Unless otherwise noted, nozzles shall be Type 316 stainless steel.

B. Each nozzle shall be furnished with a stainless steel adjustable ball fitting.

C. The distribution piping to the nozzles shall be sloped for drainage and shall be adequately supported to prevent sagging, while facilitating access for nozzle replacement. Test the system to demonstrate to the Engineer that it is entirely self-draining prior to acceptance.

D. Nozzles shall be provided as spares and shall be suitably boxed and marked for storage.

E. All nozzles shall be the appropriate model, as manufactured by Spraying Systems Incorporated or equal.

2.29 CHEMICAL DIFFUSERS

A. Chemical diffusers shall be provided for the purpose of dispersing dilute [polymer] [sodium hypochlorite] [sodium bisulfite] solutions into the process flow as indicated on the Drawings. Diffusers shall be of Schedule 80 PVC or CPVC pipe and constructed to the details shown on the Drawings.

2.30 DIFFUSER SOCKETS

A. Diffuser sockets for chemical diffusers shall locate the diffuser and help hold the diffuser in place. Sockets shall be cast iron flange and flare fittings, Fig. No. F-1440 as manufactured by Clow Corp. or equal.

2.31 APPURTENANCES AND MISCELLANEOUS ITEMS

A. All gaskets, glands, bolts, nuts and other required hardware shall be provided for connection of piping and appurtenances. Bolts and nuts shall be high strength, Type 316 stainless steel if submerged, buried, or subject to splashing and Type 304 stainless steel otherwise, with tee-head and hexagon nut. All other hardware shall be of the size, type and number as required and recommended by the piping or appurtenance manufacturer and as specified herein.

B. All gaskets for flanges shall be full face and suitable for 200degrees F operating temperature, unless higher temperature required on individual systems and the fluids carried. See also Division 1.

C. Plugs, caps and similar accessories shall be of the same material as the pipe and of the locking type, unless otherwise noted.

D. Unions shall be of the same material as the pipe, except for dielectric connections.

E. Special protective tape shall be fabric reinforced petroleum tape by Denso Inc., Houston, TX or equal.

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2.32 COLOR CODING AND LABELING

A. Color coding and labeling are specified in Section 09902.

PART 3 EXECUTION

3.01 GENERAL

A. All dirt, scale, weld splatter, water and other foreign matter shall be removed from the inside and outside of all pipe and sub-assemblies prior to installing.

B. All pipe joints and connections to equipment shall be made in such a manner as to produce a minimum of strain at the joint.

C. 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.

D. Installation of Expansion Joints and Flexible Connectors

1. Piping systems shall be aligned prior to installation of expansion fittings. Alignment shall be provided by fitting a rigid pipe spool in place of the expansion joint. Prior to testing of the piping system, the pipe spool shall be replaced with the specified expansion or flexible fitting.

2. In addition to the locations noted on the Drawings and in PART 2, expansion fittings and anchors shall be located and spaced as specified by the Expansion Joint Manufacturer's Association. The expansion joints/flexible connectors shall not be installed during times of temperature extreme or in a fully compressed or fully expanded condition.

E. Installation of Sleeve Couplings

1. Unless otherwise required by the manufacturer's instructions, prior to installation of sleeve couplings, the pipe ends shall be cleaned thoroughly for a distance of at least 12-in. Soapy water may be used as a gasket lubricant. A follower and gasket, in that order, shall be slipped over each pipe to a distance of about 6-in from the end, the middle ring shall be placed on the already installed pipe and shall be inserted into the middle ring flair and brought to proper position in relation to the pipe already installed. The gaskets and followers shall then be pressed evenly and firmly into the middle ring flares.

2. After the bolts have been inserted and all nuts have been made up fingertight, diametrically opposite nuts shall be progressively and uniformly tightened all around the joint, preferably by use of a torque wrench of the appropriate size and torque for the bolts.

3. The correct torque as indicated by a torque wrench shall not exceed 75 ft-lb for 5/8-in bolts and 90 ft-lb for 3/4-in bolts.

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4. If a wrench other than a torque wrench is used, it should be no longer than 12-in so that when used by the average person the above torque values shall not be exceeded.

5. To prevent sleeve couplings from pulling apart under pressure, a suitable harnessing or flange clamp assembly shall be provided and installed where shown on the Drawings, directed by the Engineer or required elsewhere under Division 15 concerning anchorage.

6. Note the additional locations required for sleeve couplings in PART 2. Also note Contractor's responsibility for locating, providing and installing restraints.

F. Installation of Split Couplings

1. Prior to assembly of split couplings, grooves or shoulders of the pipe as well as other parts shall be thoroughly cleaned. The ends of the pipes and outside of the gaskets shall be moderately coated with manufacturer's recommended lubricant, petroleum jelly, cup grease, soft soap, or graphite paste and the gasket shall be slipped over one pipe end. Lubricant shall be compatible with potable water application. After the other pipe has been brought to the correct position, the gasket shall be centered properly over the pipe ends with the lips against the pipes. The housing sections then shall be placed.

2. Ensure that the joints are fully extended after the rings are in place and prior to tightening the bolts. After the bolts have been inserted, the nuts shall be tightened until the housing sections are firmly in contact, as required by the manufacturer, without excessive bolt tension or strain on the pipe.

G. Installation of Pipeline Appurtenances

1. All pipeline appurtenances shall be installed as required and in accordance with the manufacturer's recommendations, as acceptable to the Engineer.

2. Gauges, meters and similar in-line items shall be isolated from testing pressures in excess of the rated pressure of the assembly.

3. Use Teflon tape on all screwed fittings.

H. Installation of Unions

1. Use unions to allow dismantling of pipe, valves, and equipment.

I. Welding

1. Welding shall be in accordance with ANSI B31 and AWS B3.0.

2. Install welding fittings on all welded lines. Make changes in direction and intersection of lines with welding fittings. Do not miter pipes to form elbows or notch straight runs to form tees, or any similar construction. Do not employ welder who has not been fully qualified in above specified procedure and so certified by approved welding bureau or similar locally recognized testing authority.

J. Installation of Flanged Joints

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1. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped. Use number and size of bolts conforming to same ANSI Standard as flanges. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces, clean gaskets and smooth all burrs and other defects. Make up flanged joints tight, care being taken to prevent undue strain upon valves or other pieces of equipment.

3.02 TESTING

A. Test all pipelines for water/gas tightness as specified in the Piping or System Sections. Furnish all labor, testing plugs or caps, pressure pumps, pipe connections, gauges and all other equipment required. Testing shall be performed in accordance with one or more of the testing procedures as specified in each Piping or System Section and Section 01445. All testing shall be performed in the presence of the Engineer.

B. Repair faulty joints or remove defective pipe and fittings and replace as approved by the Engineer. Retest.

3.03 DISINFECTION

A. After satisfactory testing, all potable and protected water systems shall be disinfected in accordance with Section 01445.

END OF SECTION

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SECTION 15140
PIPE HANGERS, SUPPORTS AND RESTRAINTS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals, and install a complete system of pipe hangers, supports, restraints, structural connections, concrete inserts, anchor bolts, and expansion units, including all hanging, restraining, expansion, and supporting devices for supporting and restraining piping as shown on the Drawings and as specified herein.

B. The absence of pipe supports, additional restraints, and details on the Drawings shall not relieve the Contractor of the responsibility for providing them. Pipe supports and restraints indicated on the Drawings are shown only to convey the intent of the design for a particular location and are not intended to represent a complete system. Not all pipe supports and restraints are indicated on the Drawings; if not shown, required pipe supports' design is included in the Contractor's scope of work.

1. Piping smaller than 12-in: Supports and restraints are shown only where specific types and locations are required; additional supports and restraint design and installation will be required and are the responsibility of the Contractor.

2. Piping 12-in and larger: Support and restraint systems are generally as indicated on the Drawings; Contractor shall provide supports as shown, but may augment or propose alternative means if they coordinate better with support products provided by the Contractor for the systems he is required to design.

C. The requirements and references of Section 15051 apply to Section 15140, although all may not be specifically indicated in Section 15140. For specific items: in case of a conflict between Section 15140 and the requirements and references of any other Sections, the requirements of individual Sections shall take precedence over Section 15140, unless specifically noted otherwise.

D. This is a Reference Section; therefore, not all the items included in Section 15140 may be required in the Project. Please refer to the Drawings for items specifically required in this Project.

E. Additional requirements for related items may be included in Sections 15400, 15410 and 15500; in case of a conflict, those Sections govern.

1.02 DEFINITIONS

A. Ferrous Metal: Iron, steel, stainless steel, and alloys with iron as principal component.

B. Wetted or submerged: Submerged, less than 1-ft above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

C. "Pipe" or "piping" shall mean all pipe, piping system(s), hose, tube, fittings, joints, valves, and similar appurtenances.

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D. Supports: wherever the word “supports” or “pipe supports” are used, they shall mean pipe supports, hangers, structural connections, concrete inserts, anchors, guides, bolts, expansion units, restraints and all restraint, hanging, supporting, allowing controlled expansion, or other means of attaching piping along with the necessary appurtenances.

E. See also Section 15051.

1.03 SUBMITTALS

A. See also Sections 15051 and 01300.

B. Shop Drawings

1. Submit complete sets of shop drawings of all items to be furnished under Section 15140, including complete layouts, schedules, location plans, and complete total bill of materials for all pipe support systems.

2. Submittals shall include a representative catalog cut for each different type of item indicating the materials of construction, important dimensions and range of pipe sizes for which that item is suitable. Complete piping drawings as submitted for each piping submittal indicating type of support, location, magnitude of load transmitted to the structure, magnitude and direction of thermal expansion and thrust forces and type of expansion fittings, anchor, guide and other pipe supporting appurtenances including structural fasteners.

3. Where standard items are not suitable, submit detailed drawings showing materials and details of construction for each type of special item. Show also revisions to support, restraint and expansion, systems resulting from changes in related piping system layout, or addition of flexible joints. Provide detailed information on anti-seize compound.

4. Submit complete design data for all systems under Section 15140 to show conformance with Section 15140.

C. Quality Control Submittals

1. Submit maintenance information on all items in Section 15140.

2. Submit support system calculations.

3. All supports and appurtenances shall conform to the latest applicable requirements of ANSI B31.1, except as supplemented or modified by the requirements of Section 15140.

D. Support System Design

1. Engage the services of an independent registered professional engineer, ordinarily engaged in the business of pipe support systems analysis, to analyze system piping and service conditions, and to develop a detailed support system, specific to the piping material, pipe joints, valves, and piping appurtenances proposed for use.

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a. The proposed support system engineer shall have at least 5 years of experience in the analysis and design of similar systems, including the use of commercial and custom pipe supports and in the use of commercial pipe stress software programs.
b. Provide the proposed support system engineer's detailed resume, including references from projects completed within the past five years. The Contractor's use of the proposed support system engineer shall be subject to the approval of the Engineer.

2. The support system design shall include:
   a. Criteria by piping system.
   b. Summary of Contractor-selected related components including joints, class, valves, appurtenances, etc., and commercial supports and especially including pipe materials.
   c. Dead weight and dynamic analysis, including system thermal effects and pressure thrusts. Computer-based software system equivalent to ADLPIPE.
      1) Each system shall be presented in an isometric graphic and shall show the resolved and resultant force and moment systems, as well as all recommended hangers, supports, anchors, restraints, and expansion/flexible joints.
   d. Submit a support system design to the Engineer for approval.
      1) After the work is installed, but before it is filled for start-up and testing, the support system design engineer shall inspect the work and shall certify its complete adequacy. Each system shall be inspected and certified in the same way.
      2) Submit a report, including all field modifications and including all certificates.
      3) The report shall bear the stamp of a professional engineer registered in the State of Tennessee and shall be subject to the approval of the Engineer.
   e. All aspects of the analysis and design shall comply with the provisions of ANSI B31.1 and the referenced standards.
   f. Support arrangements shall be coordinated to eliminate interference with similar systems to be installed under HVAC, Plumbing and Electrical; to account for structural expansion joints and to maintain access for both personnel and for the removal of equipment.

1.04 REFERENCE STANDARDS

A. Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS)

1. MSS SP58 - Pipe Hangers and Supports-Materials, Design and Manufacture

2. MSS SP69 - Pipe Hangers and Supports-Selection and Application

3. MSS SP89 - Pipe Hangers and Supports-Fabrication and Installation

B. ASTM International

1. ASTM A36 - Standard Specification for Carbon Structural Steel

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

C. American National Standards Institute (ANSI)

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1. ANSI B31.1 - Power Piping

1.05 DESIGN REQUIREMENTS

A. General

1. All supports and appurtenances shall be of approved standard design, unless otherwise acceptable to the Engineer and shall be adequate to maintain the supported load in proper position under all operating conditions. Any 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. Note that different materials required, as specified in paragraph 2.01K, may require different figures or model numbers than those shown.
   a. The minimum working factor of safety for all items, with the exception of springs, shall be 5 times the ultimate tensile strength of the material, assuming 10-ft of water-filled pipe being supported and normal test pressures.
   b. Design for all loads using a safety factor of 5.

2. All items shall be designed with liberal strength and stiffness to support, restrain and allow expansion of 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.

3. All of the equipment specified herein is intended to support, restrain and allow expansion of the various types of pipe and piping systems shown on the Drawings. It shall be the responsibility of the Contractor to develop final details and any details associated with special conditions not already covered to meet the system conditions (in particular system temperatures and pressures) specified in the respective Divisions 2, 11, 13, and 15.

4. Supports shall be sufficiently close together such that the sag of the pipe is within limits that will permit drainage and avoid excessive bending stresses from concentrated loads between supports.

5. Complete design details of the pipe system components shall be submitted for review and approval as specified in PART 1. No support shall be installed without approved support system drawings.

B. If not specified in Section 15140, related piping appurtenances shall comply with other and related requirements Sections of Divisions 2 or 15. Also, additional supports and restraints and related requirements, are indicated on the Drawings.

C. Seismic Design and restraint requirements, in accordance with the Structural Design criteria shall be included.

PART 2 PRODUCTS

2.01 GENERAL

A. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated

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requirements that piping loads shall not be transmitted to their equipment, submit certification stating that such requirements have been complied with.

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. 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 Section 15140.

C. Contractor may propose minor adjustments to the piping arrangements in order to simplify the supports, or in order to resolve minor conflicts in the work. Such an adjustment might involve minor change to a pipe centerline elevation so that a single trapeze support may be used.

D. Where flexible sleeve, split ring, vibration, or other 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 force systems to the equipment. No fixed or restraining supports shall be installed between a flexible coupling and the piece of equipment.

E. Pipe supports shall not induce point loadings but shall distribute pipe loads evenly along the pipe circumference.

F. Supports shall be provided at changes in direction and elsewhere as shown in the Drawings or as specified herein. No piping shall be supported from other piping or from metal stairs, ladders, and walkways, unless specifically directed or authorized by the Engineer.

G. Pipe supports shall be provided to minimize lateral forces through valves, both sides of flexible split ring type couplings and sleeve type couplings, and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.

H. Effects of thermal expansion and contraction of the pipe shall be accounted for in the pipe support selection and installation.

I. Insofar as is possible, floor supports shall be given preference. Where specifically indicated, concrete supports, as shown on the Drawings may be used. Base elbow and base tees shall be used where possible.

J. Restraints, flexible connections, expansion items, and related items as included in other specifications (especially Sections 15120 and other individual pipe sections) and shown on the Drawings.

K. Materials of Construction for all Supports:

1. All materials shall be certified as resistant to the fluid being carried and the location where they are installed, while providing di-electric protection between dissimilar metals and cushioning as required between metallic and non-metallic surfaces. The following shall apply unless specifically indicated otherwise, or acceptable to the Engineer.

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2. For restraints and flexible couplings as noted above.

3. For support of metallic pipe:
   a. Submerged, buried, or within outdoor structures (vaults, etc): Type 316 stainless steel.
   b. Within chemical areas: Vinyl ester fiberglass reinforced plastic (FRP) for pipe size up to 2-in, epoxy coated steel for 2.5-in size and larger.
   c. Other locations: steel with galvanizing where noted or if not otherwise noted, coating as required in Division 9; all with dielectric protection.
   d. Additional requirements (including dielectric insulation): see following paragraphs.

4. For support of non-metallic pipe:
   a. Submerged, buried, or within outdoor structures: Type 316 stainless steel or FRP.
   b. Within chemical areas: vinyl ester FRP.
   c. Other locations: steel with galvanizing where noted or if not otherwise noted, coating as required in Division 9; all with local stress protection shields.
   d. Additional requirements (including stress protection shields): see following paragraphs

5. Wherever stainless steel is noted, it shall be Type 316 unless noted otherwise.

2.02 INSULATION

A. See Paragraph 2.14 and Drawings.

B. See also Section 15250.

2.03 SUPPORT AND RESTRAINT SYSTEMS

A. Steel or Ductile Iron Piping

1. Cast iron and ductile iron, steel and stainless steel piping shall be supported at a maximum support spacing of 10-ft with a minimum of one support per pipe section at the joints.

2. Support spacing for ductile iron, steel, and stainless steel piping 2-in and smaller diameter shall not exceed 5-ft.

B. Copper Piping

1. Supports for copper pipe shall be copper plated or shall have a 1/16-in plastic coating.

2. Support spacing for copper piping and tubing 2-in and smaller diameter shall not exceed 5-ft and greater than 2-in diameter shall not exceed 8-ft.

3. Where pipe supports come in contact with copper piping, provide protection from galvanic corrosion by: wrapping pipe with 1/16-in thick neoprene sheet material and galvanized protection shield; isolators similar to Elcen, Figure No. 228; or copper-plated or PVC-coated hangers and supports.

C. Non-Metallic Piping

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1. All uninsulated non-metallic piping such as PVC, CPVC, HDPE, PVDF, etc. shall be protected from local stress concentrations at each support point. Protection shall be provided by non-metallic protection shields or other method as approved by the Engineer.
   a. Where pipes are bottom supported 180 degrees, arc shields shall be furnished. Where 360-degree arc support is required, such as U-bolts, protection shields shall be provided for the entire pipe circumference. All U-bolts or clamps for non-metallic pipes shall be plastic coated.
   b. Protection shields shall have an 18-gauge minimum thickness, not be less than 12-in in length, and be securely fastened to pipe with Type 316 stainless steel straps not less than 1/2-in wide.

2. Individually supported PVC pipes shall be supported as recommended by the manufacturer except that support-spacing shall be manufacturers recommendation minus 2-ft down to 5-ft spacing recommendation, then spacing shall be 3-ft.

3. Supports for horizontal multiple PVC plastic piping:
   a. Shall be continuous wherever possible.
   b. Multiple, suspended, horizontal plastic PVC pipe runs, where possible, shall be supported by ladder type cable trays such as: Electray Ladder by Husky-Burndy; The Globetray by the Metal Products, a Division of United States Gypsum or equal.
   c. Rung spacing shall be 12-in. Tray width shall be approximately 6-in for single runs and 12-in for double runs.
   d. Ladder type cable trays shall be furnished complete with all hanger rods, rod couplings, concrete inserts, hanger clips, etc. required for a complete support system. Individual plastic pipes shall be secured to the rungs of the cable tray by strap clamps or fasteners similar to: Globe, Model M-CAC; Husky-Burndy, Model SCR or equal.
   e. Spacing between clamps shall not exceed 9-ft. The cable trays shall provide continuous support along the length of the pipe. Individual clamps, hangers, and supports in contact with plastic PVC pipe shall provide firm support but not so firm as to prevent longitudinal movement due to thermal expansion and contraction.

D. Framing Support System

1. Beams: Size such that beam stress does not exceed 25,000 psi and maximum deflection does not exceed 1/240 of span.

2. Column Members: Size in accordance with manufacturers' recommended method.

3. Support Loads: Calculate using weight of pipes filled with water.

4. Maximum Spans:
   a. Steel and ductile iron pipe, 3-in diameter and larger: 10-ft centers, unless otherwise shown.
   b. Other pipelines and special situations: Same as noted in previous paragraphs. May require supplementary hangers and supports.

E. All vertical pipes shall be supported at each floor or at intervals of not more than 12-ft by approved pipe collars, clamps, brackets, or wall rests and at all points necessary to ensure rigid construction. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

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2.04 ANCHOR BOLTS/SYSTEMS

A. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear, and pullout loads imposed by loading and spacing on each particular support. ADHESIVE ANCHOR BOLTS SHALL NOT BE ALLOWED ON ANY PIPE SUPPORT HUNG BELOW A ROOF OR CEILING, unless specifically noted otherwise.

B. Expansion anchors shall be equal to Kwik Bolt as manufactured by Hilti USA, Tulsa, Oklahoma; or Wej-it by Wej-it Expansion Products, Inc., Broomfield, CO. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1-in behind the steel reinforcement.

C. Unless otherwise noted: use Type 304 stainless steel anchoring parts/bolts and hardware for non-submerged supports, Type 316 stainless steel for submerged anchors.

1. Size of anchor bolts as designed by manufacturer, 1/2-in minimum diameter or as shown on the Drawings.

D. Anchors to concrete in chemical areas shall be epoxy secured vinyl ester FRP all thread, insertion depth and size as required by the manufacturer for the design loads. Nuts, bolts and hardware shall all be vinyl ester FRP construction. Floor supports and anchors shall be installed prior to application of chemical resistant seamless flooring systems.

2.05 HANGER RODS

A. Paragraph 2.01 may require different materials. Where use of steel is allowed, hanger rods shall be hot-rolled steel, machine-threaded, and, except for stainless steel, galvanized after fabrication. The strength of the rod shall be based on its root diameter.

1. Hanger rods shall be attached to concrete structures using concrete inserts similar to F&S, Figures 180, 571, or 150; or continuous concrete inserts per F&S. Inserts shall be malleable iron or steel with galvanized finish.

2. Beam-clamps, C-clamps, or welded-beam attachments shall be used for attaching hanger rods to structural steel members.

B. Minimum rod size for metallic rod hangers: (* For pipe diameters less than 14-in, if using pipe roller, use 2 hanger rods with minimum diameter noted below for pipe's diameter).

1.	Nominal Pipe/		Minimum Hanger
2.	Tube Diameter		Rod Diameter
3.	Less than 2-1/2	=	1/4-in*
4.	3-in - 8-in	=	1/2-in*
5.	10-in - 14-in	=	3/4-in*

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6.	16-in - 20-in	=	2 at 1-in
7.	24-in	=	2 at 1-1/4-in
8.	30-in	=	2 at 1-1/2-in

2.06 SINGLE PIPE HANGERS

A. See Paragraph 2.01 for materials.

B. Unless otherwise indicated, pipe hangers and supports shall be standard catalogued components, conforming to the requirements of MSS-41, 58, or 69 and shall be of the following type:

1. Grinnell Co., Inc., Figure 104, 260, or 171.

2. Equal models by: B-Line; F&S Central, Brooklyn, NY; Elcen Metal Products Co., Franklin Park, IL; or Unistrut Northeast, Cambridge, MA.

C. Single pipes shall be supported by hangers suspended by hanger rods from structural steel members, concrete ceilings, bottom of trapeze hangers, and wall-mounted steel angle brackets.

D. 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 Nos. 69-68, 84, or 139 shall be used for hanging pipe. Where single pipes rest on top of bracket pipe supports, attachments shall meet requirements as specified under multiple pipe hangers.

2.07 MULTIPLE PIPE HANGERS

A. Paragraph 2.01 may require different materials than those noted below.

B. Suspended multiple pipes, running parallel in the same horizontal plane that are adjacent to each other, shall be suspended by trapeze type hangers or wall brackets. Trapeze hangers shall consist of galvanized structural steel channel (where steel is allowed) supported from galvanized threaded rod or attached to concrete walls, columns, or structural steel support members. See previous paragraphs about multiple PVC pipe supports.

C. 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, Figure Nos. 158, 419, 160A, 160B, as required. Material of construction shall be galvanized steel where allowed. 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.

2.08 SINGLE PIPE SUPPORTS FROM BELOW

A. Paragraph 2.01 may require different materials than those noted below.

B. Single pipes located in a horizontal plane close to the floor shall be Pedestal type: Schedule 40 pipe stanchion, saddle and anchoring flange.

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1. Nonadjustable Saddle: MSS SP 58, Type 37 with U-Bolt
   a. Grinnell, Figure 259.
   b. B-Line, Figure B3090.
   c. F&S, Figure 427.

2. Adjustable Saddle: MSS SP 58, Type 38 without clamp
   a. Grinnell, Figure 264.
   b. B-Line, Figure B3093.

C. Pipes less than 3-in in diameter shall be held in position by supports fabricated from steel C channel, welded post base similar to Unistrut, Figure P2072A; and pipe clamps similar to Unistrut, Figures P1109 through 26 (except see paragraph 2.01 for alternate materials required). Where required to assure adequate support, fabricate supports using two vertical members and post bases connected together by horizontal member of sufficient load capacity to support pipe. Wherever possible, supports shall be fastened to nearby walls or other structural member to provide horizontal rigidity. More than one pipe may be supported from a common fabricated support.

D. Unless otherwise noted, pipes 3-in in diameter and larger shall be supported by adjustable stanchions. Stanchions shall provide at least 4-in adjustment and be flange mounted to floor.

E. Use yoked saddles for piping whose centerline elevation is 18-in or greater above the floor and for all exterior installations.

F. Provide neoprene waffle isolation pad under anchoring.

G. Pipe roller type supports may be used where noted on the Drawings.

2.09 WALL SUPPORTED SINGLE AND MULTIPLE PIPES

A. Single or multiple pipes located adjacent to walls, columns, or other structural members shall be supported using welded steel wall brackets (except see Paragraph 2.01 for alternate material requirements) as manufactured by Grinnell, Figure 195 or Elcen, Figure 57.

B. Where noted, multiple pipes may be supported on C-channel with steel brackets similar to Unistrut pipe clamps; with pipe anchor chairs; or equal.

C. Individual pipes, up to 8-in diameter, where noted, may use MSS Type 8 pipe clamps as noted on the Drawings.

D. All members shall be securely fastened to wall, column, etc., using double-expansion shields or other method as approved by the Engineer. Additional wall bearing plates shall be provided where required.

2.10 BASE ANCHOR SUPPORT

A. Where pipes change direction from horizontal to vertical via a bend, a welded or cast base bend support (except see Paragraph 2.01 for alternate material requirements) shall be installed at the bend to carry the load. The base bend shall be fastened to the floor, pipe stanchion, or concrete pedestal using expansion anchors or other method as approved by the Engineer.

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B. Where shown on the Drawings, pipe bends shall be supported using concrete supports. Pipes shall be securely fastened to the concrete supports with suitable metal bands as required and approved by the Engineer. A neoprene insert shall be used to isolate the piping from the poured concrete.

2.11 VERTICAL PIPE SUPPORTS

A. Where vertical pipes are not supported by a Unistrut type system as specified, they shall be supported in one of the following methods. See Paragraph 2.01 for alternative materials required.

1. For pipes 1/4-in to 2-in in diameter, an extension hanger ring shall be provided with an extension rod and hanger flange. The rod diameter shall be as recommended by the manufacturer for the type of pipe to be supported. The hanger ring shall be steel- or PVC-clad depending on the supported pipe. The hanger ring shall be equal to Carpenter & Patterson, Figure Nos. 81 or 81CT. The anchor flange shall be galvanized malleable iron similar to Carpenter and Patterson, Figure No. 85.

2. For pipes equal to or greater than 2-in in diameter, extended pipe clamps similar to Carpenter & Patterson, Figure No. 267 may be used. The hanger shall be attached to concrete structures using double expansion shields or to steel support members using welding lugs similar to Carpenter & Patterson, Figure No. 220.

B. Pipe supports shall be provided for closely spaced vertical piping systems required to provide a rigid installation. The interval of vertical support spacing shall be as specified, but in no case shall vertical interval exceed 12-ft. The support system shall consist of a framework suitably anchored to floors, ceilings, or roofs.

C. Unless otherwise specified, shown, or specifically approved by the Engineer, vertical runs exceeding 12-ft shall be supported by base elbows/tees, clamps, brackets, wall rests, and pipe collars, all located as required to ensure a rigid installation.

D. Pipe riser clamps, per MSS SP58, shall be used to support all vertical pipes extending through floor slabs. Riser clamps shall be galvanized steel (unless other materials required in Paragraph 2.01) manufactured by:

1. Carpenter & Patterson, Figure No. 126.

2. Grinnell, Figure 261.

3. B-Line, Figure B3373.

4. Or equal.

E. Copper-clad or PVC-coated clamps shall be used on copper pipes. Insulation shall be removed from insulated pipes prior to installing riser clamps. Insulation shall not be damaged by clamp installation.

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2.12 SPECIAL SUPPORTS

A. Frame work supports

1. Vertical and horizontal supporting members shall be U-shaped channels similar to Unistrut, Series P1000. Vertical piping shall be secured to the horizontal members by pipe clamps or pipe straps. All components shall be of materials as previously noted. See also Paragraph 2.08.

2. For piping 3-in and smaller, the framework shall be as manufactured by the Unistrut Corporation; Globe-Strut as manufactured by the Metal Products Division of U.S. Gypsum; or equal. For piping larger than 3-in, the support frame shall be fabricated from structural steel shapes and secured through the use of drop in, adhesive or expansion anchors.

3. The assemblies shall be furnished complete with all nuts, bolts, and fittings required for a complete assembly including end caps for all Unistrut members.

4. Electrical Conduit Support: Under Division 16.

5. The design of each individual framing system shall be the responsibility of the Contractor. Shop drawings, as specified in Paragraph 1.03, shall be submitted and shall show all details of the installation, including dimensions and types of supports. In all instances the completed frame shall be adequately braced to provide a complete rigid structure when all the piping has been attached. See also Paragraph 2.03D.

B. Supports not otherwise described in Section 15140 shall be fabricated or constructed from standard structural steel shapes in accordance with applicable provisions of Section 05500 or Unistrut-type frame; have anchor hardware similar to items previously specified herein; shall meet the minimum requirements listed below; and be subject to the approval of the Engineer.

C. Additional Pipe Support Situations

1. Supporting Multiple Chemical and Related Piping:
   a. Location: indicated on Drawings or otherwise required, especially adjacent to chemical pumps.
   b. Use: framework support.
   c. Materials: FRP, with proper local stress protection.

2. Supporting Air Piping:
   a. Location: BNR Basins and as otherwise required or indicated on the Drawings.
   b. Use: Structural steel framing system in accordance with Section 05500.
   c. Materials: Galvanized structural steel.
   d. Design Loads:
      1) Dead load of piping and all appurtenances.
      2) Environmental design loads in accordance with ASCE 7 and as required on Drawing S-1, Design Criteria, including but not limited to: Snow, Wind, Seismic and Thermal effects.
      3) Pipe design loads as otherwise required in this Section.

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e. Concrete Foundations: Concrete pipe support foundations shall be designed by a Professional Engineer registered in the State of Tennessee for all applied loads from support frame in accordance with ACI 318 and the International Building Code. Frame shall not be supported from any existing or proposed structure unless approved by the Engineer.

2.13 SHOP FACTORY FINISHING

A. Prepare and prime metallic (except non-stainless steel) supports in accordance with Division 9.

2.14 ACCESSORIES

A. Insulation Shield: Install on insulated non-steel piping. Oversize the rollers and supports as required. Manufacturers: Grinnell, Figure 167; B-Line, Series B3151.

B. Welding Insulation Saddle: Install on insulated metal pipe. Oversize the rollers and supports as required. Manufacturers: Grinnell, Figure 160; or B-Line, Series B316.

C. Vibration Isolation Pad: Install under base flange of pedestal type pipe supports adjacent to equipment, and where required to isolate vibration. Isolation pads to be neoprene, waffle type, manufacturers Mason Industries, Type W; or Korfund.

D. Dielectric Barrier

1. Install between carbon steel members and copper or stainless steel pipe.

2. Install between stainless steel supports and non-stainless steel ferrous metal piping.

3. All stainless steel piping shall be isolated from all ferrous materials, including galvanized steel by use of neoprene sheet material and protection shields.

E. Electrical Isolation: Install 1/4-in by 3-in neoprene rubber wrap between submerged metal pipe and oversized clamps.

PART 3 EXECUTION

3.01 INSTALLATION

A. Proceed with the installation of piping and supports only after any building structural work has been completed and new concrete has reached its 28-day compressive strength.

B. The installation of pipe support systems shall in no way interfere with the operation of any overhead bridge cranes, monorails, access hatches, etc. No piping shall be supported from metal stairs, other pipes, ladders, and walkways unless specifically directed or authorized by the Engineer. The installed systems shall not interfere with maintenance and operational access to any equipment installed under Section 15140, or any other Section.

C. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings (within four pipe diameters), and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.

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D. Inserts for pipe hangers and supports shall be installed on forms before concrete is placed. Continuous metal inserts shall be embedded flush with the concrete surface. Before setting these items, all Drawings and figures shall be checked that have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports is included under Section 15140.

E. Apply anti-seize compound to all nuts and bolts. Supports installed without the approved compound shall be dismantled and correctly installed, at no additional cost to the Owner.

F. Support no pipe from any other pipe above it.

G. Install support systems in accordance with MSS SP69 and MSS SP89, unless shown otherwise. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.

H. Repair mounting surfaces to original condition after attachments are made.

I. Support large or heavy valves, fittings, and appurtenances independently of connected piping.

J. Brace horizontal pipes movement by both longitudinal and lateral sway bracing.

K. Where supports are required in areas to receive chemical resistant seamless flooring, install supports prior to application of flooring system.

3.02 TESTING

A. All pipe support systems shall be tested after installation in conjunction with the respective piping pressure tests. If any part of the pipe support system proves to be defective or inadequate, it shall be repaired or augmented under Section 15140 to the satisfaction of the Engineer.

3.03 FIELD FINISHING

A. Paint atmospheric exposed surfaces as specified in Division 9.

END OF SECTION

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SECTION 15250
THERMAL INSULATION FOR PROCESS EQUIPMENT & PIPING

PART 1 GENERAL

1.01 GENERAL DESCRIPTION

A. Provide all labor, materials, equipment and incidentals required to furnish and install process pipe insulation and appurtenances as indicated in released for construction design documents for the Work.

B. Coordinate insulation design and installation with design of pipe systems including piping supports and heat tracing.

1.02 QUALITY ASSURANCE

A. Reference Standards:

1. FS HH-1-558B: Insulation Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Insulation Type).

2. ASTM C 552: Standard Specification for Cellular Glass Thermal Insulation.

3. ASTM C 547: Standard Specification for Mineral Fiber Pipe Insulation.

4. ASTM B 209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

5. OSHA 1910: Occupational Safety and Health Standards.

6. NFPA 70: National Electrical Code.

B. All packaged equipment shall be independently third party labeled as a system for its intended use by a nationally recognized testing laboratory (NRTL) listed on the OSHA web site in accordance with OSHA 1910.303 and .399 as well as NFPA70, Article 90-7.

1.03 SYSTEM DESCRIPTION

A. Insulate the following piping systems:

1. Aboveground piping exposed to weather where liquid can be trapped by valve closure if freezing point less than five degrees Fahrenheit (5°F) above design minimum ambient temperature of 16°F.

2. Aboveground chemical piping within buildings where liquid can be trapped by valve closure if crystal formation temperature less than five degrees Fahrenheit (5°F) above design minimum ambient temperature of 16°F.

3. Piping carrying hot fluids with temperature greater than one hundred twenty degrees Fahrenheit (125°F), or extremely cold fluids, located in areas accessible to operating or maintenance personnel when piping in service for protection of personnel.

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4. Piping carrying hot fluids with any regulated temperature or with temperature greater than one hundred sixty degrees Fahrenheit (160°F) regardless of location.

5. Piping carrying chilled fluids with temperature more than five degrees Fahrenheit (5°F) below ambient wet bulb temperature of 92°F to prevent condensate formation on piping surfaces.

6. Any other piping where heat loss or gain would be detrimental to process requirements and/or result in additional space heating and cooling load.

B. Air Conditioning Refrigerant (ACR) piping insulation is specified in Section 15530.

C. Plumbing piping insulation is specified in Section 15460.

1.04 ADDITIONAL REQUIREMENTS - INSULATION DESIGN, INSTALLATION AND INSPECTION

A. Design of insulation systems shall include, but not be limited to, consideration of and provisions for:

1. Minimum insulation thickness in accordance with Schedule 15125 – Process Piping Insulation Thickness. Determine the appropriate amount of insulation needed based on released for construction design documents and for personnel protection as required by OHSA 1910.

2. Insulation for personnel protection for any exposed hot or cold pipe that is within 7 feet above a floor or walkway or within 15 inches measured horizontally in any direction from stairways, ramps, walkways or fixed ladders.

3. Insulation systems shall be designed to limit system radiant losses/gains to 10% under design conditions. Additionally, the following limits shall be applied:

Pipe System Type	Maximum Allowable Heat Transfer
Chilled water	40 Btu/(hr-ft^2)
Process piping affecting process control	10 Btu/(hr-ft^2)
Hot water and steam	100 Btu/(hr-ft^2)

(Reference: Nayyar, Mohinder L., ed., (2000), Piping Handbook, Seventh Edition, *McGraw-Hill, p. B.303)*

1.05 SUBMITTALS

A. Shop Drawings:

1. Submit a detailed insulation schedule including piping system, operating (fluid) temperature range, ambient (external) temperature range, insulation type, thickness, vapor barrier requirements, jacket requirements, and heat tracing (where applicable).

2. Submit scaled layout drawings clearly indicating all piping to be insulated.

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3. Submit fabrication instructions for pipe fitting and valve insulation and jacket.

B. Product Data:

1. Submit Manufacturer's literature, specifications, engineering data including thermal properties, fire hazard ratings, physical properties, and jacket type.

2. Submit installation instructions for pipe and pipe fitting insulation including jointing recommendations for butt joints and longitudinal seams.

C. Other:

1. Provide a 4-inch by 6-inch sample of material for each type of insulation, vapor barrier, and jacket furnished.

2. Certify satisfactory completion of factory tests and inspections.

PART 2 PRODUCTS

2.01 BURIED PROCESS PIPING INSULATION

A. Pipe Insulation:

1. Type: Lightweight, rigid, inorganic, impermeable, noncombustible, cellular glass insulation.

2. Certifications: ASTM C552.

3. Construction: Insulation shall be lightweight, inorganic, rigid material composed of sealed glass cells.

4. Physical Properties:
   a. Shall not retain moisture.
   b. Shall have a compressive strength of 90 psi.

5. Manufacturer:
   a. Pittsburgh Corning Corporation; FOAMGLAS Insulation System.
   b. Or equal.

B. Fitting Insulation:

1. Type: Custom-molded pipe fitting insulators.

2. Construction: Two matching half-sections.

3. Density: 7.5 pounds per cubic foot average.

4. Manufacturer:
   a. Pittsburgh Corning Corporation; FOAMGLAS Insulation System.
   b. Or equal.

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C. Weatherproof Insulation Jacket:

1. Type: Flexible, waterproof, polymer-modified bituminous membrane.

2. Construction: Shall be a heat-sealable, multiply laminate for protecting underground insulation.

3. Physical Properties: Shall have a minimum tensile strength of 100 lb/in width.

4. Thickness: 125 mil (3.2 mm).

5. Manufacturer:
   a. Pittsburgh Corning Corporation; PITTRAP Jacketing.
   b. Or equal.

2.02 EXPOSED PROCESS PIPING INSULATION (EXCEPT FOR STEAM AND CONDENSATE PIPE)

A. Pipe Insulation:

1. Type: Heavy density sectional pipe rigid fiberglass insulation jacketed with a smooth, reinforced, wrinkle-resistant, all-service vapor retarder jacket with self-sealing lap.

2. Integral Jacket:
   a. Longitudinal jacket seams: Factory applied double pressure sensitive adhesive closures shall be provided for positive mechanical and vapor sealing of the longitudinal jacket seam.
   b. Circumferential (butt) joints: Pressure sensitive butt strip seals shall be provided to complete the positive closure.
   c. Permeance: 0.15 perm., maximum.
   d. Puncture Resistance: 50 units.
   e. Composite Surface Burning Characteristics:
      1) Flame Spread 25.
      2) Smoke Developed 50.
      3) Fuel Contributed 50.

3. Manufacturer:
   a. Owens-Corning Fiberglass Corporation, SSL II ASJ and SSL I.
   b. Certain Teed.
   c. Or equal.

B. Fitting Insulation:

1. Type: Custom-molded pipe fitting insulators utilizing a thermosetting resin and fiberglass.

2. Construction: Two matching half-sections molded under high pressure and temperature.

3. Density: 4 to 6 pounds per cubic foot.

4. Thermal Conductivity: k = 0.22 maximum at 75 degrees F mean temperature.

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5. Do not provide insulation at valves, expansion joints or flowmeter insertion points in Process Air piping.

6. Manufacturer:
   a. ICA, Inc.; Hamfab Type 650.
   b. Tee Cee.
   c. Or equal.

C. Pipe Insulation Jacket and Fitting Covers:

1. Use: Provide on all insulated process piping, unless designed to receive removable jacket insulation.

2. Type: Aluminum, stucco embossed, watertight.

3. Pipe Jackets:
   a. Pre-fabricated 3105 aluminum alloy roll jacketing in conformance with ASTM B-209 with a moisture barrier coating applied to the interior and a clear corrosion protection coating applied to the exterior.
   b. Pipe jacketing shall be furnished in 36-inch long sections with seam and butt joints as specified below.
   c. Pipe jackets and joints shall be fully weatherproof and suitable for indoor and outdoor service.

4. Fitting Covers:
   a. Pre-fabricated 1100 aluminum alloy fitting cover with a moisture barrier coating applied to the interior and a clear corrosion protection coating applied to the exterior.
   b. Furnish each fitting cover in two matching halves. Field apply using screws or rivets for hot piping or strapping with a vapor barrier for cold piping.

5. Interior Moisture Barrier: 3 mil thickness of Polysurlyn (co-extrusion of polyethylene and surlyn) heat laminated (integrally bonded) to the jacketing.

6. Exterior Coating: Exterior coating shall be a clear moisture barrier with corrosion protection.

7. Thickness:
   a. Pipe Jackets:
      1) Interior: 0.016 inches, minimum.
      2) Exterior: 0.031 inches, minimum.
   b. Fitting Covers: 0.024 inches, minimum.

8. Seams and Joints:
   a. Longitudinal jacket seams: Modified Pittsburg Z-Lock.
   b. Circumferential (butt) joints: Butt strap containing a high temperature mastic secured and sealed with a fabstrap.

9. Manufacturer:
   a. Childers Products Company.
      1) Pipe Jackets: Lock-On.
      2) Fitting Covers: Ell-Jacs.

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b. Or equal.

D. Removable Jacket Insulation:

1. Use: Provide on all steam injectors, valves, couplings, flowmeters, sensors and other piping items 8'-0" above floor or less where there is no rigid fiberglass insulation system provided, but where personnel can touch or come in contact with the surface. .

2. Type: Lace-up or Velcro closure.

3. Construction: Jackets shall be a water resistant cloth.

4. Manufacturer:
   a. Advanced Thermal Corp.
   b. Pacor.
   c. Or equal.

E. Pre-Insulated Pipe Saddles:

1. Type: Preformed modified polyisocyanurate rigid foam insulation pipe saddle with a 304 stainless steel support shield.

2. Temperature Range: -200 to 300 degrees F.

3. Manufacturer:
   a. Industrial Insulation Sales, Inc.; Type A-URSA or Type M-URSA.
   b. Or equal.

2.03 EXPOSED PROCESS PIPING INSULATION (FOR STEAM AND CONDENSATE PIPE)

A. Pipe Insulation:

1. Type: Heavy density sectional pipe rigid fiberglass insulation jacketed with a smooth, reinforced, wrinkle-resistant, all-service vapor retarder jacket with self-sealing lap.

2. Integral Jacket:
   a. Longitudinal jacket seams: Factory applied double pressure sensitive adhesive closures shall be provided for positive mechanical and vapor sealing of the longitudinal jacket seam.
   b. Circumferential (butt) joints: Pressure sensitive butt strip seals shall be provided to complete the positive closure.
   c. Permeance: 0.15 perm., maximum.
   d. Puncture Resistance: 50 units.
   e. Composite Surface Burning Characteristics:
      1) Flame Spread 25.
      2) Smoke Developed 50.
      3) Fuel Contributed 50.
   f. Temperature rating to a minimum of 500°F.
   g. Insulation density shall be a minimum of 3.5 pounds per cubic foot(pcf).
   h. Insulation "k" factor shall have a minimum value of 0.29 BTU-in./Hr-Ft²-°F at a mean temperature of 200°F.

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3. Manufacturer:
   a. Owens-Corning Fiberglass Corporation, SSL II ASJ and SSL I.
   b. Certain Teed.
   c. Or equal.

B. Fitting Insulation:

1. Type: Custom-molded pipe fitting insulators utilizing a thermosetting resin and fiberglass.

2. Construction: Two matching half-sections molded under high pressure and temperature.

3. Density: 4 to 6 pounds per cubic foot.

4. Thermal Conductivity: k = 0.22 maximum at 75 degrees F mean temperature.

5. Do not provide insulation at valves, expansion joints or flowmeter insertion points in Process Air piping.

6. Manufacturer:
   a. ICA, Inc.; Hamfab Type 650.
   b. Tee Cee.
   c. Or equal.

C. Pipe Insulation Jacket and Fitting Covers:

1. Use: Provide on all insulated process piping, unless designed to receive removable jacket insulation.

2. Type: Aluminum, stucco embossed, watertight.

3. Pipe Jackets:
   a. Pre-fabricated 3105 aluminum alloy roll jacketing in conformance with ASTM B-209 with a moisture barrier coating applied to the interior and a clear corrosion protection coating applied to the exterior.
   b. Pipe jacketing shall be furnished in 36-inch long sections with seam and butt joints as specified below.
   c. Pipe jackets and joints shall be fully weatherproof and suitable for indoor and outdoor service.

4. Fitting Covers:
   a. Pre-fabricated 1100 aluminum alloy fitting cover with a moisture barrier coating applied to the interior and a clear corrosion protection coating applied to the exterior.
   b. Furnish each fitting cover in two matching halves. Field apply using screws or rivets for hot piping or strapping with a vapor barrier for cold piping.

5. Interior Moisture Barrier: 3 mil thickness of Polysurlyn (co-extrusion of polyethylene and surlyn) heat laminated (integrally bonded) to the jacketing.

6. Exterior Coating: Exterior coating shall be a clear moisture barrier with corrosion protection.

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7. Thickness:
   a. Pipe Jackets:
      1) Interior: 0.016 inches, minimum.
      2) Exterior: 0.031 inches, minimum.
   b. Fitting Covers: 0.024 inches, minimum.

8. Seams and Joints:
   a. Longitudinal jacket seams: Modified Pittsburg Z-Lock.
   b. Circumferential (butt) joints: Butt strap containing a high temperature mastic secured and sealed with a fabstrap.

9. Manufacturer:
   a. Childers Products Company.
      1) Pipe Jackets: Lock-On.
      2) Fitting Covers: Ell-Jacs.
   b. Or equal.

D. Removable Jacket Insulation:

1. Use: Provide on all steam injectors, valves, couplings, flowmeters, sensors and other piping items 8'-0" above floor or less where there is no rigid fiberglass insulation system provided, but where personnel can touch or come in contact with the surface. .

2. Type: Lace-up or Velcro closure.

3. Construction: Jackets shall be a water resistant cloth.

4. Manufacturer:
   a. Advanced Thermal Corp.
   b. Pacor.
   c. Or equal.

E. Pre-Insulated Pipe Saddles:

1. Type: Preformed modified calcium silicate rigid insulation pipe saddle with a 304 stainless steel support shield.

2. Temperature Range: Ambient to 1200 degrees F.

3. Manufacturer:
   a. Industrial Insulation Sales, Inc.; Type A-CRSA or Type M-CRSA.
   b. Or equal

PART 3 EXECUTION

3.01 PREPARATION

A. Delivery, Storage and Handling:

1. Deliver materials in Manufacturer's original packaging.

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2. All material labels or tags shall be intact and legible.

B. Protect insulating materials, at all times, from moisture.

C. Take field measurement where required, prior to installation, to insure proper fitting of Work.

D. Confirm piping, valves and fittings are clean and dry when installing insulation.

E. Complete all required pipe pressure and leak testing before beginning insulation work.

3.02 INSTALLATION

A. Apply insulation materials, accessories and finishes according to the manufacturer's written instructions; with smooth, straight and even surfaces; free of voids throughout the length of piping, including fittings, valves and specialties.

B. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften or otherwise attack insulation or jacket in either wet or dry state.

C. Seams and Seals:

1. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

2. Apply multiple layers of insulation with longitudinal and end seams staggered.

3. Do not weld brackets, clips or other attachment devices to piping, fittings and specialties.

4. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

5. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material Manufacturer. The throat seam shall be tack fastened or taped.

6. Apply insulation with the least number of joints practical.

D. Hangers, Guides and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, guides, anchors and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and guides and around anchor attachments.

2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12-inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

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4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support and shield.

5. Use pre-insulated pipe saddles with polyisocyanurate for non-steam and condensate pipe and calcium silicate for steam and condensate pipe both with a 304 stainless steel shield.

6. Provide insulation protection shields and blocks for insulated piping supported by pipe hangers and guides such that there is no metal to metal contact between pipe and hanger or guide and insulation is not crushed or otherwise deformed.

7. Provide welded insulation saddles, as required, to accommodate higher guide or anchor forces.

E. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

F. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

G. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4-inches on center.

3. Longitudinal Seams: Overlap jacket seams at least 1½-inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4-inches on center.

4. Exception: Do not staple longitudinal laps on insulation having a vapor-retarder.

5. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves and fittings.

6. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

H. Penetrations:

1. For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

2. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

3. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

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4. Floor Penetrations:
   a. Apply insulation continuously through floor assembly.
   b. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

I. Provide removable jacket insulation for pumps, blowers, flow switches, flowmeters, pressure regulators, pressure and temperature sensors, gauges, transmitters, flexible connectors, dismantling joints, expansion couplings, flexible couplings, vibration-control devices, air chambers, strainers, levers on swing check valves, plug valves, knife gate valves, process air valves and expansion joints and flow regulators.

J. Accessories:

1. Flanges and grooved-end couplings shall be insulated. Insulation shall be same as adjoining pipe mitered to fit valve contours with sealed ends.

2. All fittings shall be insulated.

3. All open ends and joints in insulation shall be sealed to prevent any fiberglass from showing and provide a positive vapor seal.

4. Provide an 8-inch unsealed slide joint as required for thermal expansion in accordance with the weatherproof insulation jacket manufacturer's recommendation.

3.03 SCHEDULE 15125 – PROCESS PIPING INSULATION THICKNESS

Process Piping System And Pipe Codes	Temperature Range	Minimum Insulation Thickness		
		Up To 2 Pipe Size	3" To 14" Pipe Size	Over 14" Pipe Size
Pre-dewatered WAS Sludge/ solids (exposed to weather) (BS)	50 to 80°F	1"	1½"	2"
Thermal Hydrolyzed Solids (THS)	170 to 210°F	1½"	2"	2½"
Compressed Air (nominal 100 psig, before after-cooler) (CA)	250 to 350°F	1"	1½"	1½"
THP Reactor Piping (at reactor(s))	200 to 350°F	1½"	2"	2½"
Medium Pressure Steam and Condensate (MPS, CMPS and VS)	350 to 400°F	1½"	2"	2½"
Dilution Water (DW), Cooling Water Supply (CWS), and City Water (CW) (exposed to weather)	53 to 81°F	1"	1½"	1½"
Cooling Water Return and Heat-Traced Process Pipe (exposed to weather)	90 to 100°F	1"	1½"	1½"
Process Chemicals (heat tracing required)	50 to 90°F	1"	1½"	1½"
Piping – not otherwise specified	Up to 200°F	1"	1½"	1½"

Comment [TJN1]: To be determined from the THP manufacturers' mass-energy balance.

Comment [TJN2]: To be determined from the THP manufacturers' mass-energy balance.

Comment [TJN3]: To be determined from the THP manufacturers' mass-energy balance.

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END OF SECTION

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SECTION 15257
ELECTRICAL HEAT TRACING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install electrical heat trace system and insulation on all outdoor exposed chemical piping; fats, oils and grease (FOG) piping; plumbing piping; valves and other piping appurtenances as shown on the Drawings and as specified herein.

B. The manufacturer shall design and supply the entire heating system, including the schematic arrangements, heating cable, junction boxes, thermostats and other equipment necessary to complete the system as shown on the Drawings and as specified herein.

C. Furnish all labor and materials necessary to install and place in satisfactory operation a complete electric heat tracing system based on the actual piping installations and the manufacturer's installation drawings and recommendations.

1.02 RELATED WORK

A. Pipe testing, cleaning and disinfection is included in Section 01445.

B. Piping and installation is included in Division 15.

C. Pipe hangers and supports are included in Division 15.

D. Pipe Insulation is included in Section 15250.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, the following calculations and information:

1. Heat loss and operating power calculations.

2. Heat tracing circuit design and loading schedule.

3. Bill of materials.

4. Catalog data sheets for all components.

5. Typical installation details.

6. Diagrams of the proposed heat tracing patterns.

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B. Submit the heat tracing system's power requirements for the design condition (extreme minimum ambient at required maintain temperature) and for the normal operating temperature (normally expected minimum ambient).

1.04 REFERENCE STANDARDS

A. The system shall be suitable for the specified industrial conditions, and shall be designed and installed in accordance with the latest applicable codes and standards. Pertinent standards are:

1. American National Standards Institute (ANSI)

2. Institute of Electrical and Electronics Engineers (IEEE)

3. American Society for Testing and Materials (ASTM)

4. National Fire Protection Association (NFPA)

5. National Electrical Code (NEC)

6. Factory Mutual (FM)

7. Underwriters Laboratories (UL)

8. National Electrical Manufacturers Association (NEMA)

9. Occupational Safety and Health Administration (OSHA)

B. Furnish copies of the necessary approvals for the heat tracing system and verify that the approvals are current.

C. 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 heat tracing system manufacturer shall be required to demonstrate a minimum of 5 years experience in the design and manufacture of industrial heat tracing systems similar to those described in this Section and shown on the Drawings.

B. The system manufacturer shall employ capable personnel to provide detail engineering, coordination, drafting and start-up services and shall provide warranty compliance for the period specified.

C. All heat tracing equipment furnished under this Section shall be supplied by a single manufacturer and shall have a minimum of 5 years of proven successful operation in the field under environmental conditions similar to those that will be encountered under the scope of this work.

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1.06 MANUFACTURERS SERVICE

A. Provide manufacturer's technical and design services to layout the proposed heat tracing system and prepare shop drawings and information to be submitted under the requirements of this Section.

1.07 HAZARDOUS AREA CLASSIFICATION

A. Supply a heating system which is suitable for the specified industrial and electrical classification and shall be designed and installed in accordance with the latest local and/or National Electrical Code regulations.

B. Where heat tracing is installed in hazardous locations as shown on the Electrical Drawings, all heat tape, boxes, thermostats, etc. shall be suitably rated and approved for the designated classified area in which it is installed. The installations shall be in compliance with National Electrical Code. The heat trace designer shall indicate the hazardous locations on the heat trace design drawings and submittal.

1.08 DESIGN REQUIREMENTS

A. Provide a heating system capable of maintaining the specified temperature during the extreme of ambient temperature.

B. Design Parameters

1. Voltage Available 120 Volts Single Phase

2. Wind Velocity 30 mph

3. Low Ambient Temperature 0 degrees F

4. Maintain Temperature

a. Freeze Protection Systems: 50 degrees F, except caustic which is 60 degrees F

b. Fats, Oils & Grease (FOG) Piping Heating Systems: 100 degrees F

5. Piping and equipment lists and insulation types and thicknesses are found in Division 15 and on the Drawings.

C. Heat losses shall be calculated using the manufacturer's standard procedure in conjunction with the insulation requirements and equipment schedules. The design heat output of the tracing shall include a 10 percent factor of safety. Contractor is encouraged to suggest changes in insulation thickness to optimize total system economy.

D. Heating cables shall be run parallel to the pipe only. Spiral wrapping of the heat cables around the pipes shall not be permitted.

1.09 APPLICATIONS

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A. The term "Freeze Protection System" shall mean the heating system installed on equipment such as pipes, valves, pumps, gauges, and controls to prevent the fluid from freezing when the ambient or surrounding temperature falls below 32 degrees F (0 degrees C). Freeze protection shall be provided for all outdoor exposed piping with a diameter of 8-inches or less except as noted on the Drawings. Air piping is excluded from this requirement.

B. The term "Fats, Oils & Grease (FOG) Piping Heating System" shall mean the heating system installed on all FOG-handling equipment such as pipes, valves, pumps, gauges, and controls to prevent the FOG from congealing inside the equipment.

C. Parallel resistance self-limiting heat tracing cable shall be used for piping freeze protection system. The tape shall be rated 5 watts per foot at 50 degrees F.

D. When heating cables are installed in hazardous areas indicated on the Drawings, they shall be UL or FM listed for use in the particular atmosphere and degree of hazard involved.

E. The temperature of the heating cables shall be automatically controlled by line type thermostats specified herein. The thermostats shall switch a contactor to power the heating cables.

PART 2 PRODUCTS

2.01 MATERIALS

A. Parallel Resistance Self-Regulating Cable

1. The heater design shall be such that it can vary its output in response to temperature variations along a pipe due to heat sinks such as fittings or pipe supports, or changes in ambient conditions such as those occurring on pipes passing into or out of buildings or process areas. This variable output feature shall apply to each increment of the heater independent of each other increment.

2. Heat tracing should be of a type which can be field cut-to-length without any cold spots and can be overlapped at all power outputs without burning out.

3. The heat tracing should be capable of continuous reliable operation when hanging loose in free air during equipment removal or replacement.

4. The cable shall not require the use of heat transfer cement or compounds.

5. The cable shall operate on standard voltages without the use of special transformers. Line voltage fluctuations shall not appreciably affect the cable wattage output.

6. Heat tracing shall be a type which can be field designed to accommodate changes in field piping without compromising its FM or UL approvals.

B. Control Thermostats

1. Control thermostats shall be UL listed, heavy duty, industrial bulb and capillary type housed in a watertight, NEMA 4X cast aluminum enclosures (NEMA 7 rated for hazardous locations). Thermostats shall be provided with independently adjustable dual switches for

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control and low temperature alarm. Contact rating shall be 22 Amps, 480 Volts, resistive. Bulb and capillary shall be stainless steel, 10-ft long.

C. Power connection kits and junction boxes shall be NEMA 4X watertight cast aluminum (NEMA 7 rated for hazardous locations).

D. The heat tracing system shall be manufactured by Chemelex, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Heat tracing system shall be installed in accordance with manufacturer's approved shop drawings and recommendations.

B. Heating cables shall be run parallel to the pipe only. Spiral wrapping of the heat cables around the pipes shall not be permitted.

C. Power cables for heat tracing circuits running from the supply panel to circuit junction boxes located on each pipe shall be run in conduit. The heat tracing cable shall connect to the power cable in a junction box and be routed onto the pipe through a cable feeder connector with gland nut. The connector shall be two-piece construction with a tapered neoprene bushing and recessed flame-resistant interior gland. The connector shall be attached to the pipe with stainless steel J.B. support and pipe strap.

D. At each point where the junction box is attached to the lagging for heating cable entry to the pipe or device being protected and after the heating cable has been installed, the junction box stand-off shall be filled with clear Dow Corning TRV-732 compound or equal rated 500 degrees F, to provide a waterproof connection. The sealant compound shall also be forced into the voids in the insulation which were created during installation of the conduit hub. The sealant compound shall be placed to position all cables away from standoff sides and to separate cables away from one another. The sealant compound shall be applied in a clean, neat manner and in strict accordance with the manufacturer's instructions for the sealant. When the installation is complete, check that none of the compound has been left on other than the prescribed areas.

E. Install "electrically traced line" warning signs every 25-ft along the outer pipe insulation jacket, Chemelex catalog number "ETL".

3.02 TESTING

A. Measure the resistance of heating cable system before and after pipe insulation.

B. Adjust and seal control thermostats to Owner's and Engineer's satisfaction after installation is complete.

END OF SECTION

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SECTION 15754
STAINLESS STEEL CONCENTRIC TUBE HEAT EXCHANGERS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish cooling heat exchangers with all accessory equipment and auxiliaries specified in this Section, including long radius elbows, flanged nozzles with pressure and temperature gauge ports, sludge and water transfer pipe couplings, drain and vent ports, and steel structural frames and supports. Design and furnish all anchor bolts and other attachments required to properly attach the units to the support building structure.

B. Operating Conditions

A. The digested solids are expected to have solids concentrations of 4.5 to 6.5 percent solids by weight.

B. The thermally hydrolyzed solids feed to the digesters is expected to have solids concentrations of 8.0 to 12.0 percent solids by weight, including potential dilution water that can be added at the end of the Thermal Hydrolysis Process. The dilution water feed rate is set by the operators based upon sampling of the sludge.

C. The cooling water will be plant reuse water.

C. Design and Performance Requirements

A. Each heat exchanger shall be concentric tube (tube-in-tube) type, with sludge flow in the inner pipe and water flow in the annular (outer tube) side of the heat exchanger, with water flow direction countercurrent to the sludge flow.

B. Each heat exchanger shall be supported on fabricated galvanized steel bases provided by the manufacturer of the heat exchangers (Manufacturer).

C. Heat Exchanger Configuration:

Comment [TJN1]: To be determined after selection of THP System Supplier.

D. The design temperature for the cooling water supply shall be as listed in Specification 11351. The heat exchangers shall be designed to operate with any cooling water supply temperature between and including the minimum and maximum temperatures.

E. The approach temperature (difference between hot side inlet and cold side outlet temperatures) shall be less than 20 °F at the design cooling capacities specified and with maximum cooling water supply temperature of 81 °F.

F. The system shall be capable of recycling digested solids at a rate to maintain turbulent flow in cooling heat exchanger and heat exchanger performance under all feed conditions. The design sludge velocity through the inner pipe of the heat exchangers shall be 5.0 ft/s minimum under all operating conditions.

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G. The combined cooling water supply design flow to the cooling heat exchangers shall not exceed 750 gpm in total for maximum ambient and effluent temperature conditions.

H. Heat exchangers shall be designed based on a design viscosity of 35 centipoises, which was assumed based on available information.

I. Heat exchangers shall have the ability to be isolated, flushed, and cleaned with solutions of sodium hydroxide, sodium carbonate or other cleaning solution. Both the solids side and water side of the heat exchangers shall meet this requirement. Connection ports and isolation valves shall be provided for cleaning solutions to be circulated through either side of the heat exchanger without emptying the associated cooling water piping and solids piping. Piping material that will be in contact with the cleaning solution shall be the same material as the heat exchangers.

J. Both the sludge side and water side of the heat exchangers shall have the ability to be physically "rod" cleaned.

K. The heat exchanger shall be designed, fabricated, tested, stamped and certified in compliance with the ASME Code, Section VIII, Division 1 and ASME Code, Section IX. The heat exchangers shall be hydrostatically tested to the following conditions.
   A. The sludge piping (inner tube) shall be tested for a working pressure of 100 psi.
   B. The water piping (outer tube) shall be tested for a working pressure of 100 psi.
   C. Medium used for testing: water
   D. Test duration: 120 minutes
   E. Leakage allowance: zero leakage
   F. Testing pressure equal to 1.5 times the working pressure

L. The cooling heat exchangers shall be designed for cooling of a mixture of thermally hydrolyzed solids feed and digested solids recycle, and shall meet the following additional requirements:
   A. Basis of design: The combined cooling heat exchanger capacity shall be XX Million BTU/hr, required for cooling 28 dry tons per day (dtpd) of thermally hydrolyzed solids at XX percent total solids from a temperature of XXX °F before mixing with digested solids to a temperature of 100°F. The corresponding recycle ratio of digested solids to thermally hydrolyzed solids shall be 4:1 or higher if required in order to maintain the specified minimum velocity of 5.0 feet per second (fps) at the conditions specified above as basis of design.
   B. Each cooling heat exchanger shall be designed for the following design conditions:

1)	Heat transfer removal capacity:	XX Million BTU/hr cooling
2)	Number of sludge passes in series:	X
3)	Number of water loops:	X per sludge pass
4)	Number of sludge/water tube bundles:	X
5)	Tube bundle inner sludge pipe nominal size:	4"
6)	Tube bundle outer water pipe nominal size:	6"
7)	Vertical water transfer pipe nominal size:	4"
8)	Sludge velocity per sludge tube:	5.0 fps
9)	Water velocity in tube annulus:	XX fps

Comment [TJN2]: To be determined by THP System Suppliers mass balance.

Comment [TJN3]: To be determined by THP System Suppliers mass balance.

Comment [TJN4]: To be determined by THP System Suppliers mass balance.

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10) Water velocity in vertical transfer pipe: XX fps
11) Inlet sludge temperature: XXX °F
12) Discharge sludge temperature: XXX°F
13) Entering water temperature: 54°F to 81°F
14) Maximum width: 6'-0"
15) Maximum length: 24'-0" (including return elbows)
16) Maximum pressure drop through water side: XX psi under all operating conditions.
17) Maximum pressure drop through sludge side: XX psi under all operating conditions.

Comment [TJN5]: To be finalized after selection of THP System Supplier

M. Anchor bolts and support attachments:
   A. Design all anchor bolts and support attachments for all applied loads, including but not limited to self weight, content load, operating loads, thermal loads, thrust, wind, and seismic loads.
   B. Seismic loads shall be determined in accordance with IBC Chapter 16 seismic design category D.
   C. The design of all anchor bolts shall be performed under the supervision of a professional engineer registered in the State of Tennessee. Anchor bolt calculations shall be signed and sealed by a professional engineer registered in the State of Tennessee.

1.02 REFERENCES

A. The following references identify codes and standards applicable to the HEX equipment:

   A. ANSI B16.5 - Pipe Flanges and Flanged Fittings

   B. ANSI B16.11 - Forged Fittings, Socket-Welding and Threaded

   C. ANSI B36.19M - Stainless Steel Pipe

   D. ASME Section VIII, Division 1 - Boiler and Pressure Vessel Code; Rules for Construction of Pressure Vessels

   E. ASME Section IX - Boiler and Pressure Vessel Code; Welding and Brazing Qualifications

   F. ASTM A36 - Structural Steel

   G. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings

   H. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

   I. ASTM A182/A182M - Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

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J. ASTM A193/A193M - Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

K. ASTM A194/A194M - Carbon and Alloy Steel Nuts for Bolts for High Pressure and High-Temperature Service

L. ASTM A240 - Heat-Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels

M. ASTM A276 - Stainless and Heat-Resisting Steel Bars and Shapes

N. ASTM A312/A312M - Seamless and Welded Austenitic Stainless Steel Pipes

O. ASTM A320/A320M - Alloy Steel Bolting Materials for Low-Temperature Service

P. ASTM A351/A351M - Standard Specification for Castings, Austenitic, for Pressure Containing Parts

Q. ASTM A354 - Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.

R. ASTM A403/A403M - Wrought Austenitic Stainless Steel Piping Fittings

S. ASTM A409/A409M - Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service

T. ASTM A480/A480M - General Requirements for Flat-Rolled Stainless and Heat- Resisting Steel Plate, Sheet and Strip

U. ASTM A572 – Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel

V. ASTM A774/A774M - As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures

W. ASTM A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot- Dip Galvanized Coatings.

X. ASTM A992 – Standard Specifications for Structural Steel Shapes

Y. ASTM F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi yield strength

Z. AWWA 606 - Standard for Grooved and Shouldered Joints

AA. AWS D1.1 - Structural Welding Code—Steel

B. Other technical specifications specifically related to this specification include:

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A. Section 11000 - General Requirements for Equipment

1.03 PREPARATION AND SHIPMENT

A. Commodity Materials: Prepare, package, and protect features and characteristics that are essential for their intended use in the Work from damage due to handling or transport.

B. Equipment Assemblies:

A. Factory assemble equipment when practical. Furnish equipment parts and assemblies that are shipped unassembled with an assembly plan and instructions. Match-mark or tag separate parts and assemblies in a manner to facilitate field assembly.

B. Protect machined and unpainted parts subject to damage by the elements with an application of a strippable protective coating. Furnish all equipment with suitable eyebolt lifting lugs or lifting angles to facilitate handling.

C. Package or crate equipment in a manner that will provide protection from damage during shipping, handling, and storage. Securely wrap and cover during shipment equipment too large to be shipped in a closed container with both a clear sturdy plastic and a tarpaulin.

D. Mark or tag outside of package or crate to indicate contents by name and Equipment number; approximate weight; special precautions for handling; and recommended requirements for storage prior to installation.

1.04 SHIPMENT AND HANDLING

A. Schedule: Provide at least seven days advance notice to Contractor of anticipated delivery date to the Plant.

A. Transport and handle products in accordance with manufacturer's instructions.

B. Coordinate delivery times with Contractor to avoid conflicts with plant operations and minimize congestion on public roads in the general vicinity of the Plant.

B. Repair or replace any items damaged during shipment.

1.05 QUALITY ASSURANCE

A. Qualifications:

A. All shop fabricated stainless steel pipe and fittings shall be furnished by a single manufacturer who is experienced and qualified in the manufacture and fabrication of the items to be furnished. The pipe and fittings shall be shop-fabricated and field-installed in accordance with common industry wide practices and methods and shall comply with these specifications.

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B. Only weld procedures which have been qualified under ASME Section IX and only welders who have successfully completed performance qualification tests per ASME Section IX on these qualified procedures shall be utilized.

B. Testing:

A. Factory testing shall conform to the requirements of ASTM A312 depending on the size and type of stainless steel pipe provided.

1.06 SOURCE QUALITY CONTROL

A. Provide at least thirty (30) days written notice to Contractor and Owner of the place and time for shop or factory testing to confirm compliance before shipment with fabrication, manufacturing, or performance requirements applicable to an equipment assembly or system included in the Work.

B. Arrange access to manufacturer's facility, test personnel, and calibration records when Contractor and/or Owner choose(s) to witness specific shop tests.

1.07 SUBMITTALS

A. Submit copies of all materials required to establish compliance with this Section. Submittals shall include the following:

A. Source Quality Control: Shop and factory testing notices (situational prior to shipment when testing required).

B. Manufacturer's Service Representative Reports:
A. Daily log (situational during installation).
B. Certification of proper installation (situational after installation complete).
C. Commissioning report (situational after completion of adjustments and tuning to place equipment in service).

C. Testing Plan: Submit written description of proposed testing methods, procedures, and apparatus to Contractor at least 30 days in advance of testing.

D. Test Reports and Procedures, in accordance with applicable sections of Appendix XX: Submit certified test report for each test, including tests certifying the test pressure, duration of the test, and system performance.

E. Certified shop and erection drawings showing all important details of construction, installation requirements, dimensions and anchor bolt locations. Outline dimensions of each heat exchanger assembly showing provisions for field disassembly as required for periodic maintenance along with connection and anchorage requirements.

F. Working Drawings: Dimensioned drawings showing coordination of heat exchanger assemblies with sludge piping, water piping, controls, supports, and accessories with clearances required for periodic maintenance.

Comment [TJN6]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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G. Calculations and drawings for the design of all anchor bolts, including diameter and embedment length and details, and attachments to the supporting building structure. Calculations and drawings shall bear the seal of a professional engineer registered in the State of Tennessee.

H. Descriptive literature, bulletins and/or catalogs of the equipment. Heat exchanger flow rates and pressure loss data for cooling water and blend of thermally hydrolyzed solids and digester solids.

I. Data on characteristics and performance of the units developed for the specific application to indicate ability to meet specified design and operating requirements and characteristics.

J. The total weight of the equipment, including the weights of the larger components.

K. A complete total bill of materials for all equipment. Include list of all parts (including manufacturer's part numbers), material of construction and O&M part numbers for all purchased parts.

L. Complete description of surface preparation and galvanizing.

M. Operating and Maintenance Data as described in Specification -1730. Standard operations and maintenance instructions typically provided by equipment manufacturers will not be accepted as fulfilling this requirement.

N. Warranties and Equipment Maintenance Agreement: Letter from Manufacturer confirming proper installation, proper commissioning, performance limits, covered components, and warranty effective dates.

O. A factory representative who has complete knowledge of proper operation and maintenance of the heat exchanger shall be provided to instruct representatives of the Owner on proper operation and maintenance as described in Paragraph 3.02.

P. Manufacturer's technical data sheets for each coating product.

Q. Submit sample panel(s) for all anticipated surface types such as fabricated steel.

R. Test reports and records of all field testing.

B. Submit Manufacturer's Certificate of Compliance with the Contractor's specifications.

C. Submit Manufacturer's certification of the proper erection (installation), testing, start-up (commissioning) and operation equipment supplied under this Specification.

1.08 SPARE PARTS, SPECIAL TOOLS, AND SUPPLIES

A. No spare parts or special tools shall be provided for the equipment specified in this Section.

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1.09 WARRANTY

A. Equipment Manufacturer shall warrant to the Contractor or Owner that the equipment purchased from Equipment Manufacturer is free from defects in material and workmanship for a period of twelve (12) months from the date of acceptance by Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers include Olympus Technologies, JDV Equipment Corporation, and WesTech Engineering.

2.02 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Piping, Stainless	Stainless Steel Type 316L, ASTM A312
Structural steel	ASTM A36, ASTM A572 and ASTM A992, Galvanized

B. Structural Steel shall be galvanized.

A. All structural steel components shall have a Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A123.

B. Galvanizing Repair Paint ASTM A780.

C. Materials specified establish the minimum acceptable criteria for the purposes of durability, strength, and resistance to erosion and corrosion. Alternative materials for the purpose of providing greater strength or to meet required stress limitations must provide at least the same qualities of durability, strength, and resistance to erosion and corrosion as those specified.

D. Design, fabricate and assemble all equipment in accordance with the most modern engineering and shop practice. Manufacture individual parts to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall be new and shall not have been in service at any time prior to delivery, except as required by tests. Select materials of construction suitable for service conditions indicated.

E. Except where otherwise specified, structural and miscellaneous fabricated steel used in items of equipment shall conform to the Standards of the American Institute of Steel Construction. All structural members shall be considered as subject to shock or vibratory loads.

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2.03 WELDING AND BRAZING

A. All welds shall be sound and free from embedded scale and slag. All butt welds shall be continuous, and where exposed to view, shall be ground smooth. All continuous welds shall be gas and liquid-tight. Welds in piping shall have full penetration and shall be smooth on the inside of the pipe. Intermittent welds shall have an effective length of at least 2-inches and shall be spaced not more than 6-inches apart.

B. All welding of steel and aluminum, including materials, welding techniques, general safety practices, appearance and quality of welds, and methods of correcting defective work, shall conform to the latest requirements of AWS Specifications. Structural steel and aluminum welding shall conform to the applicable requirements of the AWS Structural Welding Code. The welding process and welding operators shall meet qualification tests and welding performance tests in accordance with the latest provisions of ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications. Welding process and qualification procedures for welding of pipe shall conform to the latest requirements of ANSI B31.1, Section 327, Welding, and Section 328, Brazing and Soldering.

2.04 NAMEPLATES

A. Provide each piece of equipment with a nameplate made of noncorrodible metal securely fastened in place and clearly and permanently inscribed with the manufacturer's name, model or type designation, serial number, principal rated capacities, electrical or other power characteristics, and similar information as appropriate.

2.05 EQUIPMENT

A. Description:

A. All materials in contact with sludge and cooling water shall be Type 316L stainless steel. Pipe shall have shop-welded circumferential, full penetration, butt-weld joints; flanges; or grooved-end couplings. The sludge tubes shall be connected by 180° long radius, full passageway return bends. Water shall be transferred between jackets by short tubes, connected by grooved-end couplings, preventing leakage from one fluid to the other. The water tubes shall be attached to a heavy duty structural steel support structure with fixed and expandable connectors. Return bends shall be removable from either end of the sludge tubes. Inlet and outlet connections shall be flanged and may be attached to the heat exchanger with grooved end couplings. Heat exchanger shall be equipped with threaded couplings for recessed thermometer wells in the sludge inlet, cold water inlet, sludge outlet, and water outlet of each unit.

B. The tuning and cooling heat exchangers shall have a single sludge pass. A water supply connection port (no less than 1-1/2”) and drain connection (no less than 2”) shall be provided at the beginning and end of each sludge pass to flush and drain each pass when not in use.

C. Stainless steel piping shall be seamless or welded annealed austenitic stainless steel. The piping material shall be ASTM A312 Grade TP 316L, full finish. Only extra-low carbon

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(ELC) materials with 0.035 percent maximum carbon shall be used. A maximum of one longitudinal weld seem per section shall be used in fabrication. Longitudinal weld seams shall be shop welded by the tungsten inert gas or metallic inert gas method with no filler material. All interior welds shall be ground smooth to provide an internal head of 1/16 inch or less. Pipe shall be manufactured to nominal pipe sizes as listed in ANSI B36.19. The minimum wall thickness of piping shall be Schedule 10S.

D. Stainless steel fittings, 2-1/2-inches and smaller, shall be ASTM A403, of the same material and pressure rating as the pipe, threaded long radius with dimensions conforming to ANSI B16.11 and ASME B1.20.1 (thread form). Fittings shall be Class 150 with a cold working pressure rating of 300 psi and a saturated steam rating of 150 psi. Threaded pipe, gage, or instrument connections shall be made using stainless steel, minimum Class 2000, threaded half-couplings conforming to ASTM A182 or ASTM A276, shop welded to the pipe at the locations specified.

E. Stainless steel fittings, 3-inch and larger, shall be butt-weld type manufactured in accordance with ASTM A774 of the same material and in the same thicknesses as the pipe. Long radius elbows up to 24 inches in diameter shall be smooth flow. Elbows shall have a minimum wall thickness of Schedule 40S. Reducers shall be straight tapered, cone type. Flanges shall be Class 150 forged Type 316L stainless steel and shall be raised face conforming to ANSI B16.5 and ASTM A182.

F. Gaskets for ANSI flange connections on sludge piping shall be UL approved 316 stainless steel reinforced spiral wound graphite and rated for the specified service.

G. Bolts, nuts and washers shall be ASTM A354, Type 316 stainless steel including anchor bolts.

H. Grooved-end or split type couplings shall conform to AWWA 606. Grooved-end or split type couplings for sludge side shall be ASTM A351, 316 stainless steel Victaulic Style 489. Grooved-end or split type couplings for water side shall be ASTM A351, 316 stainless steel Victaulic Style 489 or ASTM A 47, malleable iron Victaulic Style 07. Reducing couplings for the water side shall be Victaulic Style 750. The pipe ends shall be roll-grooved to the coupling manufacturer's specifications. Where roll grooving is impractical, the pipe shall have heavy-wall machine-grooved pipe nipples or machined ring collars fully welded to the pipe or fitting. Nipples shall be taper-bored to the I.D. of the adjoining pipe to allow full-weld penetration. Collars shall be welded on both sides to the piping. Nipples and collars shall be of the same alloy as the piping. Coupling gaskets for water side shall be UL approved EPDM compound, rated for 200 psig and 230 °F service. Coupling gaskets for sludge side shall be UL approved flush-seal type Viton (fluoroelastomer), rated for 200 psig and 230 °F service.

PART 3 EXECUTION

3.01 TESTING OF PIPING

A. General:

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A. Hydrostatic testing shall be performed by Manufacturer at their facility.

B. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls within the upper half of the gage's range.

C. Hold the specified test pressure for the specified period.

D. Repair and retest system which fails to hold specified test pressures or which leaks.

E. Slowly fill section to be tested with water and expel all air. Install corporation cocks as necessary to remove air.

F. Inspect all valves, joints and specials for tightness and for proper operation while under test pressure.

G. Pipe test pressures shall be as submitted in the associated test plans.

3.02 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Provide the services of a qualified, factory trained and field experienced engineer/technician who is an authorized service representative of the manufacturer to perform the following services for all equipment assemblies unless otherwise indicated in individual technical requirement sections. Notify Contractor and Owner in writing seventy-two (72) hours for each instance prior to performance of these manufacturers' services.

A. Supervise installation of all equipment assemblies. Submit a copy daily of the service representative's log of all activities related to each installation.

B. Inspect equipment assemblies after installation and before commissioning to confirm readiness for operation. Submit the service representative's certification that the equipment is properly installed, is ready for permanent operation, and satisfies all requirements to maintain warranty coverage.

C. Supervise initial operation, testing, balancing and adjustment to commission equipment for normal operation. Submit a commissioning report, which includes detailed descriptions of the points inspected, tests and adjustments made, quantitative test results, and maintenance recommendations

3.03 SUMMARY OF HEAT EXCHANGER SYSTEM SUPPLIER'S SERVICES

A. Appendix XX to the Contract between the Contractor and the Owner establishes pretesting, functional testing, commissioning and acceptance testing requirements.

B. Equipment manufacturer shall provide the services of factory trained specialists to assist the Contractor during testing and commissioning activities, including assistance with preparation of all required documentation, data summaries, plans and reports, as specified in this Section and in Appendix XX to the Contract.

Comment [TJN7]: Appendix XX, "Functional and Performance Testing" covers the entire Biosolids process, and won't be available until later in the design. See Attachment F for information on Performance Guarantees, Functional Testing, Commissioning and Acceptance Testing associated with the THP system.

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C. Equipment manufacturer shall indicate below the number of man-days on-site and trips to the worksite necessary to meet the requirements specified in this Section and in Appendix XX to the Contract. All durations shall be exclusive of travel time.

A. Prerequisite Documentation Stage
   A. Provide services during installation:

Minimum Number of trips to the site:	1
Minimum Number of man-days at the site per trip:	2
Number of additional trips to the site	($/trip)
Number of additional man-days at the site per trip	($/man-day)

   B. Conduct pre-requisite testing and provide certification that the equipment is ready for operation:

Minimum Number of trips to the site:	1
Minimum Number of man-days at the site per trip:	1
Number of additional trips to the site	($/trip)
Number of additional man-days at the site per trip	($/man-day)

B. Pre-Start Inspection Stage, Functional Testing, Commissioning Activities and Acceptance Testing
   A. Provide support services, assistance with testing activities and preparation of plans, documentation and reports:

Minimum Number of trips to the site:	0
Minimum Number of man-days at the site per trip:	0
Number of additional trips to the site	($/trip)
Number of additional man-days at the site per trip	($/man-day)

D. In case of component failure, equipment manufacturer shall provide all necessary additional labor, tests, materials and equipment required for repair or replacement of the malfunctioning equipment at no additional cost to Contractor.

E. The durations listed above shall be for the purpose of establishing a minimum standard of service. They shall not relieve the equipment manufacturer of his obligation to meet the requirements specified in this Section.

END OF SECTION

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SECTION 16000

ELECTRICAL - GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

Where the word "Contractor" appears in this Division of the Specifications, it shall be construed to mean the Electrical Contractor. The requirements of the Contract and Divisions 0, 1, 2 and 3 shall also apply to the Electrical Contractor.

A. Furnish all labor, materials, equipment and incidentals required and install complete and make operational, electrical and process instrumentation systems at the City of Franklin Waste Water Treatment Plant as shown on the Drawings and as specified herein.

B. The work shall include furnishing, installing and testing the equipment and materials specified in other Sections of the Division 16 Specifications and shown on the Drawings.

C. The work shall include furnishing and installing the following:

1. Electrical services from the Power Company.

2. Conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions of these specifications.

3. Conduit, wiring and terminations for all field-mounted instruments furnished under other Divisions of these specifications, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions of these specifications.

4. Power wiring for all heating, ventilating, and air conditioning (HVAC) equipment furnished under other Divisions of these Specifications, including power wiring for 120V unit heater motors, thermostats, fan motors, dampers and other HVAC inline unit wiring shown on the Drawings.

5. Furnish and install precast manholes, precast handholes and light pole bases.

6. Furnish and install manhole and handhole frames and covers.

7. It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this Section shall be furnished at no extra cost.

8. Modifications to existing control systems including installation of auxiliary motor starter contacts, relays, switches, etc, as required to provide the control functions or inputs as shown on the Drawings. Obtain the existing equipment shop drawings from the Owner before attempting to make any modifications to the existing equipment wiring. Verify all

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existing wiring and connections for correctness. If record drawings are not available, trace all circuits in the field and develop the wiring diagrams necessary for completion of the work. Document all changes made to the wiring diagrams and return a marked-up set of Record Drawings to the Owner after the work is complete.

9. Coordinate the sequence of demolition with the sequence of construction to maintain plant operation in each area. Remove and demolish equipment and materials in such a sequence that the existing and proposed plant will function properly with no disruption of treatment.

10. Modifications to existing motor control centers, switchboards, panelboards and motor controllers including installation of circuit breakers, etc, or disconnection of circuits as required to provide the power supplies to new and existing equipment to maintain the plant in operation.

D. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the existing site, buildings and structures in which work under this Division is to be performed and inspect carefully the present installation. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the site, buildings and structures and noted the locations and conditions under which the work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work.

E. Provide all electrical demolition work associated with the removal of equipment from the existing facilities, including disconnecting and removing all electrical wiring and conduit to equipment being removed under other sections. Survey the existing electrical systems with representatives from other trades prior to performing any demolition work. Identify all conduit and equipment to be removed with tags or paint.

F. Buildings or structures scheduled for complete demolition shall be made safe from electrical shock hazard prior to demolition. Disconnect all electrical power, communications, alarm and signaling systems. Remove only specific electrical equipment noted for removal and turn over to the Owner. All other miscellaneous electrical materials, equipment, etc, will be demolished and removed from the site as specified in Division 2.

G. Provide all electrical relocation work associated with the relocation of equipment for the existing and new facilities, including disconnecting all existing wiring and conduits and providing new wiring and conduit to the relocated equipment.

H. All power interruptions to electrical equipment shall be at the Owner's convenience and as required in Section 01014. Each interruption shall have prior approval.

I. The Contractor shall maintain the existing plant in operation at all times. Temporary power connections as required shall be provided by the Contractor at no additional expense to the Owner. All temporary wiring shall be in accordance with the NEC. Any temporary equipment feeders (120/208V, 480V, 5KV) shall be installed in conduit. The Contractor shall provide to the Engineer details, methods, materials etc. prior to making temporary connections. Furnish and install all equipment and materials including control equipment, motor starters, branch and feeder circuit breakers, panelboards, transformers, etc., for temporary power. A temporary power plan shall be submitted to the Engineer for approval.

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J. Field verify all existing underground electrical and mechanical piping.

K. The Contractor shall prepare and furnish electrical and instrumentation conduit layout shop drawings for yard electrical, within and under all roads, buildings and structures to the Engineer for approval prior to commencing work. Layouts shall include but not be limited to equipment, pull boxes, manholes, conduit routing, dimensioning, methods and locations of supports, reinforcing, encasement, materials, conduit sizing, equipment access, potential conflicts, building and yard lighting, and all other pertinent technical specifications for all electrical and instrumentation conduits and equipment to be furnished. All layouts shall be drawn to scale on 24 x 36 sheets. Refer to Division 16000, 1.03, H for additional requirements.

L. The work shall include complete testing of all equipment and wiring at the completion of work and making any minor correction changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

M. A single manufacturer shall provide switchgear, motor control centers, transformers, disconnect switches, unit substations, panel boards, etc. This manufacturer shall also provide a short circuit/coordination study as specified herein.

N. Contractor shall provide their own temporary power for miscellaneous power (drills, pumps, etc.). No facility circuits shall be used unless approved in writing by the Engineer. Any temporary added shall be removed at job completion.

O. Complete coordination with other contractors. Contractor shall coordinate with all other contractors' equipment submittals and obtain all relevant submittals.

P. Mount control panels, transmitters, process instruments, operators stations, etc. furnished under other Divisions of these specifications.

Q. Concrete electrical duct encasement, including but not limited to excavation, concrete, conduit, reinforcement, backfilling, grading and seeding is included in Division 16. All work shall be done in accordance with Divisions 2 and 3 of these specifications.

R. Excavation, bedding material, forms, concrete and backfill for underground raceways; forms and concrete for electrical equipment furnished herein is included in Division 16. All work shall be done in accordance with Divisions 2 and 3 of these specifications.

S. The contractor shall include in the base bid the following miscellaneous wiring, including installation costs. (Assume all conduit shall be considered exposed at elevations up to 20 feet and include all necessary pull boxes, supports, etc.)

1. 1,000 feet of 4 No. 12 – ¾ inch GRS conduit

2. 1,000 feet of 2 No. 14 – ¾ inch GRS conduit

3. 1,000 feet of 2/C No. 16 shielded – ¾ inch GRS conduit

1.02 RELATED WORK

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A. Excavation and backfilling, including gravel or sand bedding for underground electrical work is specified in Division 2.

B. Cast in place concrete work, including concrete encasements for electrical duct banks, equipment pads, light pole bases and reinforcing steel, is specified in Division 3.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, shop drawings for equipment, materials and other items furnished under Division 16.

B. Shop drawings shall be submitted for the following equipment:

1. Raceways, Boxes, Fittings and Hangers

2. Wires and Cables

3. Miscellaneous Equipment (as specified in Section 16191)

4. 5KV Switchgear

5. Pad Mounted Transformers

6. Panelboards

7. 480V-Motor Control Centers

8. 4160V-Motor Control Centers

9. Lighting Fixtures and Lamps

10. Switches, Receptacles and Covers

11. Precast Manholes and Handholes, Frames and Covers

12. Grounding Hardware and Connections

13. Diesel Engine Driven Generators

C. The manufacturers name and product designation or catalog numbers shall be submitted for the following material utilized:

1. Testing Equipment

2. Ground System Resistance Test Equipment

D. Check shop drawings for accuracy and contract requirements prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform the Specifications and the Drawings. This statement shall also list all

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exceptions to the Specifications and the Drawings. Shop drawings not so checked and noted shall be returned.

E. The Engineer's check shall be for conformance with the design concept of the project and compliance with the Specifications and the Drawings. Errors and omissions on approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by the Specifications and the Drawings.

F. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.

G. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered or shop work started if shop drawings are marked "APPROVED AS NOTED - CONFIRM", "APPROVED AS NOTED - RESUBMIT" or "NOT APPROVED".

H. In addition to manufacturer's equipment shop drawings, submit electrical installation working drawings containing the following:

1. Concealed and buried conduit layouts, shown on floor plans drawn at not less than 1/4-in = 1-ft-0-in scale. The layouts shall include locations of process equipment, motor control centers, transformers, panelboards, control panels and equipment, motors, switches, motor starters, large junction or pull boxes, instruments and any other electrical devices connected to concealed or buried conduits.

2. Plans shall be drawn on high quality reproducible, double sided mylar, size 36-in by 24-in and shall be presented in a neat, professional manner.

3. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved.

I. Operation and Maintenance Data

1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Section 01730. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc, to instruct operating and maintenance personnel unfamiliar with such equipment. Complete electronic versions of each manual shall be provided in addition to hard copies.

2. Manuals shall include the following as a minimum:

a. A comprehensive index.

b. A complete "As-Built" set of approved shop drawings.

c. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.

d. A table listing of the "as left" settings for all timing relays and alarm and trip setpoints.

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e. System schematic drawings "As-Built", illustrating all components, piping and electric connections of the systems supplied under this Section.

f. Detailed service, maintenance and operation instructions for each item supplied.

g. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

h. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.

i. Complete parts list with stock numbers, including spare parts.

1.04 REFERENCE STANDARDS

A. Electric equipment, materials and installation shall comply with the latest edition of National Electrical Code (NEC) and with the latest edition of the following codes and standards:

1. National Electrical Safety Code (NESC)

2. Occupational Safety and Health Administration (OSHA)

3. National Fire Protection Association (NFPA)

4. National Electrical Manufacturers Association (NEMA)

5. American National Standards Institute (ANSI)

6. Insulated Cable Engineers Association (ICEA)

7. Instrument Society of America (ISA)

8. Underwriters Laboratories (UL)

9. Factory Mutual (FM)

10. International Electrical Testing Association (NETA)

11. Institute of Electrical and Electronic Engineers (IEEE)

B. All electrical equipment and materials shall be listed by Underwriter's Laboratories, Inc., and shall bear the appropriate UL listing mark or classification marking. Equipment, materials, etc. utilized not bearing a UL certification shall be field or factory UL certified prior to equipment acceptance and use.

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

1.05 PRIORITY OF THE CONTRACT DOCUMENTS

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A. If, during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and the Drawings, furnish the higher performance requirements. The higher performance requirement shall be considered the equipment, material, device or installation method which represents the most stringent option, the highest quality or the largest quantity.

B. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the Engineer and work not particularly shown, identified, sized, or located shall be the same as similar work that is shown or specified.

C. Detailed Drawings shall govern over general drawings, larger scale Drawings take precedence over smaller scale Drawings, Change Order Drawings shall govern over Contract Drawings and Contract Drawings shall govern over Shop Drawings.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Engineer.

E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.06 ENCLOSURE TYPES

A. Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings:

1. NEMA 1 for dry, non-process indoor locations.

2. NEMA 12 for "DUST" locations.

3. NEMA 4X for outdoor locations, rooms below grade (including basements and buried vaults), "DAMP" and "WET" locations.

4. NEMA 4X for "CORROSIVE" locations.

5. NEMA 7 (and listed for use in the area classifications shown) for "Class I Division 1 Group D", "Class I Division 2 Group D" and "Class II Division 1" hazardous locations shown on the Drawings.

1.07 SERVICE AND METERING

A. The Power Company serving this project is Duke Energy. Service will be obtained at 4160 Volts, 3 Phase, 3 Wire, 60 Hz (resistance grounded) to the service entrance equipment as

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shown on the drawings. Pay all fees and charges as required to obtain temporary and permanent service. Coordinate with Duke Energy to provide and meet requirements for these services.

B. Furnish and install the primary, service conduits, secondary service conduits, substation service riser, secondary service conductors, connectors, busing, etc. to extend the service(s) to the generator/electrical building transformer vault.

C. The Contractor shall be responsible for the following work:

1. Make all arrangements with the power company for obtaining electrical service, pay all power company charges and furnish all labor and material required for the electrical service.

2. Furnishing and installing the secondary transformer termination risers, busing, etc. per Duke Energy requirements. Riser, terminations, etc. shall be adequate for future cabling.

3. Furnishing secondary conduits and cables and all necessary terminations.

4. Furnishing and installing a power company approved metering current transformers and required enclosures.

5. Installing meter base and necessary metering conduits as required by Duke Energy.

1.08 HAZARDOUS AREAS

A. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503.

B. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

1.09 CODES, INSPECTION AND FEES

A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.

B. Obtain all necessary permits and pay all fees required for permits and inspections.

1.10 TESTS AND SETTINGS

A. Test systems and equipment furnished under Division 16 and repair or replace all defective work and equipment. Refer to the individual equipment sections for additional specific testing requirements. Employ the services of an independent recognized power systems testing company, other than the manufacturer of the switchgear or motor control centers, to perform the tests specified herein.

B. Field testing and commissioning shall be performed in accordance with the latest revisions of NETA Standard ATS "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" unless otherwise modified by these Sections.

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C. A typed test report for each component tested shall be submitted to the Engineer for the project record files. The firm doing the testing shall include, in the report, their opinion whether or not the equipment being tested complies with the specification. Any discrepancies shall be noted in the concluding summary of the report. Test report forms shall be in compliance with NETA standards. A minimum of three complete copies shall be provided. Reports shall be signed by the person in responsible charge of the field testing, an officer of the firm performing the tests and an officer of the Electrical Contractor.

D. Make adjustments to the systems and certify all protective relay, breakers, etc. settings have been set in accordance with the coordination study. A certified copy of the settings data sheets shall be included in the final report.

E. In addition to the specific testing requirements listed in the individual sections, the following minimum tests and settings shall be performed.

1. Mechanical inspection, testing and settings of circuit breakers, disconnect switches, motor starters, overload relays, control circuits and equipment for proper operation.

2. Check the full load current draw of each motor. Where power factor correction capacitors are provided the capacitor shall be in the circuit at the time of the measurement. Check ampere rating of thermal overloads for motors and submit a typed record to the Engineer of the same, including MCC cubicle location and driven load designation, motor service factor, horsepower, and Code letter. If incorrect thermal overloads are installed replace same with the correct size overload.

3. Check power and control power fuse ratings. Replace fuses if they are found to be of the incorrect size.

4. Check settings of the motor circuit protectors. Adjust settings to lowest setting that will allow the motor to be started when under load conditions.

5. Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication.

6. Check rotation of motors prior to testing the driven load. Disconnect the driven equipment if damage could occur due to wrong rotation. If the rotation is incorrect for the driven equipment correct motor connections at the motor terminal box.

7. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by control schematic and wiring diagrams.

8. Inspect each piece of equipment in areas designated as HAZARDOUS to ensure that equipment of proper rating is installed.

9. Verify all terminations at transformers, equipment, panels and enclosures by producing a 1, 2, 3 rotation on a phase sequenced motor when connected to "A", "B" and "C" phases.

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10. Check all wire and cable terminations. Verify to the Engineer connections meet the equipments torque requirements.

11. Field set all transformer taps as required to obtain the proper secondary voltage.

12. Infra-red hot spot inspection shall be made of all electrical equipment including but not limited to switchgear, motor control centers, transformers, switches, power and control panels, etc. This shall be done under representative load conditions before the equipment is used by the Owner and again 3 months before expiration of the 1-year warranty period.

F. Make the following minimum tests and checks prior to energizing electrical equipment. Submit test reports upon completion in accordance with Section 01300.

1. Test and calibrate protective relays and circuit breakers.

2. Over potential, high potential, insulation resistance and shield continuity tests for medium voltage cables as specified in Section 16121.

3. Mechanical inspection of air interrupter switches and circuit breakers to assure proper operation.

G. Testing shall be scheduled and coordinated in writing with the Engineer at least 2 weeks in advance. The testing firm shall provide all material, labor, equipment and technical supervision to perform the tests and inspection. Provide certified calibration sheets including dates for all equipment to be used for testing with notice of scheduled testing. Calibration sheets shall also indicate that the units have been calibrated within six months of the testing date. The Contractor shall have qualified personnel present during the testing.

1.11 PROTECTIVE DEVICES COORDINATION & ARC FLASH STUDY

A. General:

1. The major electrical equipment manufacturer (i.e. switchgear, transformer and motor control centers) shall provide a computerized Power System Study and Arc Flash analysis for the electrical power distribution and motor control equipment. The study shall verify adequacy of all of the existing equipment as well as new additions being implemented under these Specifications.

2. The study shall also include the utility company's protective devices, the emergency generators, the main switchgear, all feeders from the main switchgear, all substations and distribution and all associated MCC's. Graphic indication of coordination shall be furnished in the form of a clearly labeled and identified composite drawing showing time-current curves of system protective devices. Time-current curves of each device shall also be furnished.

3. The Contractor/Manufacturer shall be responsible for obtaining and verifying with the Power Company in writing all information needed to conduct this study. Provide this correspondence and information including contacts and phone numbers with the study submittal.

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4. The Contractor shall set all protective devices and relays based on this coordination study to provide coordinated, selective protection for all equipment supplied or affected by the installation under this Contract.

5. The Contractor/Manufacturer shall provide data necessary to perform the study. This includes feeder cable sizes, approximate feeder length, motor data, switchgear data, existing protective relay settings and any other information relevant to the study.

6. A summary of the short circuit analysis shall be provided to the Contractor at the time shop drawings for all of the new equipment is submitted for approval.

7. The manufacturer shall be made aware that there is no available up-to-date single line diagram for the existing facility. The Contractor/Manufacturer shall provide and/or update the existing single line diagram as required in order to perform the coordination and short-circuit study.

B. Scope:

1. The power system study consists of four major parts. The first part is the preliminary short circuit study. The preliminary short circuit study shall verify new and existing equipment is being applied with design ratings. Shop drawings for new equipment will not be reviewed until the preliminary short circuit study is approved by the Engineer.

2. The second and third parts of the power system study include the final short circuit and protective device coordination study. New equipment shall not be energized until this study is approved by the Engineer and devices are set in the field in accordance with the study.

3. The fourth and final part of the power system study is the arc flash study. The arc flash study labels shall be added after the equipment is energized and all changes, upgrades or modifications have been made, to ensure field labeling will be accurate.

4. The short circuit study shall be in accordance with ANSI Standard C37.010 and C37.13, shall be performed to check the adequacy, and to verify the correct application of circuit protective devices and other system components specified. The study shall address the case when the system is being powered from the normal source as well as from the on-site generating facilities. Minimum as well as maximum possible fault conditions shall be adequately covered in the study.

5. Fault contribution of all motors shall be considered. The Contractor shall be responsible for obtaining all required data of equipment. All back-up calculations shall become part of the final report. The Calculations shall be in sufficient detail to allow easy review.

C. Contents:

1. The study shall include representation of the power company's systems, the base quantities selected, impedance source-data, calculation methods and tabulations, one-line and impedance diagrams, conclusions and recommendations. Short circuit momentary duties, shall be calculated on the basis of an assumed bolted three-phase short circuit at each medium voltage bus, low voltage switchboard bus, switchboards, motor control centers,

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distribution panelboards, pertinent branch circuit panelboards, and other significant locations through the systems. The short-circuit tabulations shall include significant X to R ratios, asymmetry factors, KVA, and symmetrical fault current.

2. A protective device time current coordination study shall be included with coordination plots of key and/or limiting devices, tabulated data, rating, and/or settings selected. The study shall present an engineering balance between the competing objectives of protection and continuity of service for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.

3. Separate plots shall be provided for each mode of "normal" and "stand-by" operation. Maximum fault values shall be shown in each case. Both power sources shown in one plot will not be accepted.

4. Existing protective device settings shall be reviewed to ensure selectivity under the new conditions. Recommended changes shall be indicated in the report. The Contractor shall be made aware of required changes immediately.

5. Transformer damage curves in accordance with ANSI C57.109.

6. Feeder cable damage curves.

7. Required settings for breakers and relays shall be maximized to provide the most effective protection possible whether the system is fed from the normal or emergency source.

8. Tabulations indicating recommended set points for all protective devices shall be provided. This shall include the normal as well as the emergency source.

9. An executive summary outlining the distribution system, the information received from the utility company, assumptions made to complete the study, statement of the adequacy of the distribution equipment to safely clear or close on any fault, and identification of any problem areas with recommendations for resolving the problem

10. Generator short circuit decrement curves and thermal limit curves shall be included.

11. Tabulation of arc flash information.

12. Load flow analysis.

D. Motor Current-Time Characteristic Curves:

1. A complete independent set of current-time characteristic curves for all medium voltage motor drives indicating coordination between the protective relays and the thermal characteristics of the motor shall be provided.

2. The Contractor shall obtain from the motor supplier, the necessary information to perform the study. Certified curves for "safe time versus current at 100 percent voltage" and "accelerating time versus current at 100 percent voltage" shall become part of the final report.

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E. Motor Starting Study:

1. A motor starting study for all large electric drives (100 horsepower and above) to determine voltage dip or power inrush limitations at selected locations due to starting of motors shall be provided. This applies to both the normal and the emergency mode.

F. General Information for Time-Current Curves Presentations:

1. The coordination plots shall include complete titles, representative one-line diagrams, legends, associated power company's relay or system characteristics, significant motor starting characteristics, complete parameters for power, and substation transformers, and complete operating bands for low-voltage circuit breaker trip devices.

2. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required.

3. The short-time region shall indicate the medium voltage relay instantaneous elements, the magnetizing in-rush, and ANSI withstand transformer parameters, the low-voltage circuit breaker instantaneous trip devices, fuse manufacturing to tolerance bands, and significant symmetrical and asymmetrical fault currents.

4. Each primary protective device required for a delta-to-wye connected transformer shall be selected so that the characteristic or operating band is within the transformer parameters; which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line-to-ground faults.

5. Low-voltage power circuit breakers shall be separated from each other and the associated primary protective device, where feasible, by a 16 percent current margin for coordination and protection in the event of secondary line-to-line faults.

6. Protective relays shall be separated, where feasible, by a 0.3 second time margin when the maximum three-phase fault flows, to assure proper selectivity.

G. Generator(s) Protective Devices:

1. The study shall address all of the new and existing protective devices provided for generator protection.

2. Protective relays requiring settings shall include, but not necessarily limited to:

a. Differential

b. Overcurrent with voltage restraint

c. Ground

d. Undervoltage

e. Reverse power

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f. Unbalanced loading and open phase

g. Loss of excitation

3. Contractor shall obtain all necessary new and existing generator information to perform this study.

H. Arc Flash Study:

1. The study shall utilize the fault current values calculated in the short circuit study and the clearing time of the upstream protective device in the coordination study to calculate the incident energy at each fault location.

2. Study shall be in accordance with IEEE Standard 1584 and NFPA 70E.

3. Study shall calculate the incident energy and flash protection boundary at all significant locations in the electrical distribution system (switchgear, switchboards, motor control centers, panelboards) where work could be performed on energized parts. Include any 208 volt or 240 volt equipment that is fed from transformers greater than 75 kVA.

4. Incident energy calculations shall include maximum and minimum fault contribution scenarios, since protective device clearing times can vary greatly depending upon the fault current.

5. Tabulations shall be provided showing each fault location, the arcing fault magnitude, protective device clearing time, duration of the arc, arc flash boundary, working distance, incident energy and hazard risk category

I. The coordination study shall be bound in a standard 8-1/2" x 11" size report and submitted in accordance with Section 01300. The final selection of all protective devices shall be based on a preliminary draft of the coordination study which shall be submitted with the equipment shop drawings for review. The completed study shall be submitted to and approved by the Engineer before any of the equipment is shipped. All protective devices shall be adjusted, tested, and calibrated in the field, prior to energizing the equipment, per the settings listed in the study. This work shall be performed by the manufacturer as described in this section and prior to final acceptance by the Owner.

J. All protective devices, existing and new shall be calibrated and tested as recommended by and under the supervision of the distribution gear manufacturer's representative as specified in this section.

K. The coordination study shall be stamped and signed by a professional engineer registered in the state in which the equipment is to be installed.

L. Arc Flash Warning Labels:

1. Provide a machine printed 3.5-inch x 5-inch thermal transfer type label of high adhesion polyester for each location identified in the arc flash study.

2. Labels shall include the following machine printed information (hand lettering is not

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acceptable): equipment name, flash hazard boundary, incident energy, boundaries for shock hazard, limited approach, restricted approach and prohibited approach, PPE (personal protective equipment) category and date.

3. One label shall be required at each applicable low voltage switchgear, switchboard, motor control center or panelboard. One label shall be required at each medium voltage motor control center, switchgear, or switch.

1.12 INTERPRETATION OF DRAWINGS

A. The Drawings are not intended to show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.

B. Install each 3 phase circuit in a separate conduit unless otherwise shown on the Drawings.

C. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.

D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.

E. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation. Any adjustments required in the field shall be provided at no additional cost to the Owner and coordinated and approved by the Engineer.

F. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the Contractor and approved by the Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of the approved equipment at no additional cost to the Owner.

H. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his/her own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his/her own or others, caused by such redesign.

I. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by 2 inch spacers to provide a clearance between wall and equipment.

J. All floor mounted electrical equipment shall be placed on 4-inch thick (3/4-inch, 45 degree chamfer at all exposed edges) concrete pads, provide reinforcement, anchors, etc.

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K. The Contractor shall harmonize the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc, required to accomplish this shall be furnished and installed by the Contractor without additional expense to the Owner. In case interference develops, the Engineer is to decide which equipment, piping, etc., must be relocated, regardless of which was installed first.

1.13 PHASE BALANCING

A. The Drawings do not attempt to balance the electrical loads across the phases. Circuits on motor control centers and panelboards shall be field connected to result in evenly balanced loads across all phases.

B. Field balancing of circuits shall not alter the conductor color coding requirements as specified in Section 16120.

1.14 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

1.15 RECORD DRAWINGS

A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "Record Drawings". Record drawings shall be provided in electronic format (latest release of AutoCadd)

B. Record Drawings shall accurately show the installed condition of the following items:

1. One-line Diagram(s).

2. Equipment elevations (front views).

3. Raceways and pullboxes.

4. Conductor sizes and conduit fills.

5. Panel Schedule(s).

6. Control Wiring Diagram(s).

7. Lighting Fixture Schedule(s).

8. Lighting fixture, receptacle and switch outlet locations.

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9. Underground raceway and duct bank routing.

10. Plan view, sizes and locations of switchgear, distribution transformers, substations, motor control centers and panelboards.

C. Submit a schedule of control wiring raceways and wire numbers, including the following information:

1. Circuit origin, destination and wire numbers.

2. Field wiring terminal strip names and numbers.

D. In addition to the schedule, provide point-to-point connection diagrams showing the same information submitted in the schedule of control wiring raceways including all designations and wire numbers.

E. Submit the record drawings, schedule of control wiring raceways and wire numbers and the point-to-point connection diagrams to the Engineer. The schedule of control wiring raceways and wire numbers and the point-to-point connection diagrams shall be computer generated (i.e. no hand-written or drawn schedules, drawings, or diagrams will be accepted).

1.16 EQUIPMENT INTERCONNECTIONS

A. Review shop drawings of equipment furnished under other Divisions and prepare coordinated wiring interconnection diagrams or wiring tables. Submit copies of wiring diagrams or tables with the Record Drawings.

B. Furnish and install all equipment interconnections.

1.17 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be new, except where specifically identified on the Drawings to be re-used.

B. Material and equipment of the same type shall be the product of one manufacturer and shall be UL listed.

C. All equipment furnished under Division 16 shall be warranted for a period of one year by the Contractor and Manufacturer. Warranty period shall commence as outlined in the General Conditions and Division 1.

D. The Manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.

1.18 EQUIPMENT IDENTIFICATION

A. Identify equipment (disconnect switches, separately mounted motor starters, control stations, etc) furnished under Division 16 with the name of the equipment it serves. Motor control

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centers, control panels, panelboards, switchboards, switchgear, junction or terminal boxes, transfer switches, etc, shall have nameplate designations as shown on the Drawings.

B. Nameplates shall be engraved, laminated plastic, not less than 1/16-in thick by 3/4-in by 2-1/2-in with 3/16-in high white letters on a black background.

C. Nameplates shall be screw mounted to NEMA 1 enclosures. Nameplates shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two sided foam adhesive tape is not acceptable. Where the equipment size does not have space for mounting a nameplate, the nameplate shall be permanently fastened to the adjacent mounting surface. Cemented nameplates shall not be drilled.

D. All voltages (e.g. 4160 volts, 480 volts, 120/208, etc.) within pull boxes, junction boxes etc. shall be identified on the front exterior cover. Signs shall be red background with white engraved lettering, lettering shall be a minimum of 1" high.

E. All pull boxes, junction boxes, etc. shall be provided with a master nameplate. The nameplate shall include respective pull box name/number; voltage contained within pull/junction box; circuits contained to and from locations.

1.19 DEMOLITION

A. Remove electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused.

B. Remove unused exposed conduit and wiring back to point of concealment including abandoned conduit above accessible ceiling finishes. Remove unused wiring in concealed conduits back to source (or nearest point of usage).

C. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide stainless steel blank covers for abandoned outlets which are not removed.

D. Disconnect and remove abandoned panelboards, transformers, disconnect switches, control stations, distribution equipment, etc.

E. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers and other accessories.

F. Disconnect electrical circuits in the way of demolition work and re-establish circuits to remaining outlets, fixtures, equipment, etc. Disconnect electrical systems in walls, floors and ceilings scheduled for removal.

G. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.

H. New lighting shall be in place or safe lighting levels maintained for plant operation during the construction period.

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I. Repair adjacent construction and finishes damaged during demolition and extension work.

J. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or be suitably relocated and the system restored to normal operation.

K. Coordinate outages in systems with the Owner. Where duration of proposed outage cannot be allowed by the Owner, provide temporary connections as required to maintain service.

L. Removal and relocation of existing conduit, wire and equipment have not been detailed on the Drawings. Survey the affected areas before submitting bid proposal.

M. Trace out existing wiring that is to be relocated, or removed and preform the relocation or removal work as required for a complete operating and safe system.

N. Continuous service is required on all circuits and outlets affected by these changes, except where the Owner will permit an outage for a specific time. Obtain Owner's consent before removing any circuit from continuous service.

O. Remove exposed conduits, wireways, outlet boxes, pull boxes and hangers made obsolete by the alterations, unless specifically designated to remain. Patch surfaces and provide stainless steel blank covers for abandoned outlets which are removed.

P. All equipment, materials, controls, motor starters, branch and feeder breakers, panelboards, transformers, wiring, raceways, etc, furnished and installed to temporarily keep circuits energized shall be removed when the permanent installation is fully operational.

Q. Electrical Removal

1. All existing electrical equipment and fixtures to be removed shall be removed with such care as may be required to prevent unnecessary damage, to keep existing systems in operation and to maintain the integrity of the grounding systems.

2. Conduits and wires shall be abandoned or removed where shown. All wires in abandoned conduits shall be removed, salvaged and stored. Abandoned conduits concealed in floor or ceiling slabs or in walls, shall be cut flush with the slab or wall at the point of entrance. The conduits shall be suitably plugged and the area repaired in a flush, smooth and approved manner. Exposed conduits and their supports shall be disassembled and removed from the site. Repair all areas of work to prevent rust spots on exposed surfaces.

3. Wall switches, receptacles, and other miscellaneous electrical equipment, shall be removed and disposed of off the site as required. Care shall be taken in removing all equipment so as to minimize damage to architectural and structural members. Any damage incurred shall be repaired.

1.20 DISPOSITION OF REMOVED MATERIALS AND EQUIPMENT

A. In general, it is intended that material and equipment indicated to be removed and disposed of by the Contractor shall, upon removal, become the Contractor's property and shall be disposed of off the site by the Contractor, unless otherwise directed by the Owner. Any fees or charges

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incurred for disposal of such equipment or materials shall be paid by the Contractor. A receipt showing acceptable disposal of any legally regulated materials or equipment shall be given to the Owner.

B. Ballasts in each existing lighting fixture shall be assumed to contain PCB's unless specifically marked with a label indicating "No PCBs". Remove ballasts from each lighting fixture and pack them in accordance with EPA PCB regulations. Ship ballasts in approved containers to an EPA approved recycling facility and pay all shipping, packaging and recycle costs.

1.21 SAFETY REQUIREMENTS

A. The Contractor shall make every effort to keep all employees and/or subcontractors aware of the danger inherent in working in dangerous proximity to the existing power lines. The minimum recommended precautionary measures are as follows:

1. Make sure that all persons responsible for operating cranes, draglines and other mobile equipment have a copy of, and are familiar with the State Department of Commerce Regulations for Use of Cranes, Draglines and Similar Equipment Near Power Lines, as well as the U.S. Department of Labor OSHA Regulations, before commencing operation of said equipment.

2. Make sure that all cranes, draglines and other mobile equipment have attached to them the black and yellow Department of Commerce warning signs required by the said Regulations of State Department of Commerce.

3. Warn all employees on the ground, new and old employees alike, of the danger of holding on to or touching a cable or other piece of equipment or machinery that is located or working close to any overhead power line.

4. If, during the course of construction, it becomes necessary for the contractor, or subcontractor, and their employees, to operate cranes, draglines, or their mobile equipment, in dangerous proximity of any overhead power lines, or in such a manner that such equipment might come close to any overhead power lines, the Contractor shall give the Power Company or overhead power line owner prior notice of such proposed operation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate the concealed conduit before the floor slab is poured.

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C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

D. Seal all openings, sleeves, penetration and slots as specified in Section 16110.

3.02 CUTTING AND PATCHING

A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete as specified in Section 01045. Sawcut concrete and masonry prior to breaking out sections.

B. Core drill holes in existing concrete floors and walls as required.

C. Install work at such time as to require the minimum amount of cutting and patching.

D. Do not cut joists, beams, girders, columns or any other structural members.

E. Cut opening only large enough to allow easy installation of the conduit.

F. Patching to be of the same kind and quality of material as was removed.

G. The completed patching work shall restore the surface to its original appearance or better.

H. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

I. Remove rubble and excess patching materials from the premises.

J. When existing conduits are cut at the floor line or wall line, they shall be filled with grout of suitable patching material.

3.03 INSTALLATION

A. Any work not installed according to the Drawings and this Division or without approval by the Engineer shall be subject to change as directed by the Engineer. No extra compensation will be allowed for making these changes.

B. Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry permanent shelters. If an apparatus has been damaged, such damage shall be repaired at no additional cost. If any apparatus has been subject to possible injury by water, it shall be replaced at no additional cost to the Owner, the damaged unit(s) or systems shall remain on site and returned to the manufacturer after the replacement unit(s) or systems have been delivered to the site. Under no circumstances will electrical equipment damaged by water be rehabilitated or repaired, new equipment shall be supplied and all cost associated with replacement shall be borne by the Contractor.

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C. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion.

D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted per the field painting requirements Section 09902, at no additional cost to the Owner.

3.04 MANUFACTURERS SERVICE

A. Provide manufacturer's services for testing and start-up of the following equipment:

1.	4160 Volt Switchgear	(6 days 2 trips minimum)
2.	480 Volt Switchgear	(6 days 2 trips minimum)
3.	Liquid Filled Substation Transformers	(6 days 2 trips minimum)
4.	Pad Mounted Transformers	(2 days 1 trip minimum)
5.	480 Volt Motor Control Centers	(2 days 1 trip minimum)

B. Testing and startup shall not be combined with training. Testing and start-up time shall not be used for manufacturers warranty repairs.

C. The manufacturers of the above listed equipment shall provide experienced Field Service Engineer to accomplish the following tasks:

1. The equipment shall be visually inspected upon completion of installation and prior to energization to assure that wiring is correct, interconnection complete and the installation is in compliance with the manufacturer's criteria. Documentation shall be reviewed to assure that all Drawings, operation and maintenance manuals, parts list and other data required to check out and sustain equipment operation is available on-site. Documentation shall be red-lined to reflect any changes or modifications made during the installation so that the "as-built" equipment configuration will be correctly defined. Spare parts shall be inventoried to assure correct type and quantity.

2. The Field Service Engineers shall provide engineering support during the energization and check-out of each major equipment assembly. They shall perform any calibration or adjustment required for the equipment to meet the manufacturer's performance specifications.

3. Upon satisfactory completion of equipment test, they shall provide engineering support of system tests to be performed in accordance with manufacturer's test specifications.

4. A final report shall be written and submitted to the Contractor within fourteen days from completion of final system testing. The report shall document the inspection and test activity, define any open problems and recommend remedial action. The reports after review by the Contractor shall be submitted to the Engineer.

3.05 TRAINING

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A. Provide manufacturer's services for training of plant personnel in operation and maintenance of the equipment specified under Division 16.

1.	4160 Volt Switchgear	(5 days 2 trips minimum)
2.	480 Volt Switchgear	(5 days 2 trips minimum)
3.	Liquid Filled Substation Transformers	(1 day 1 trip minimum)
4.	Pad Mounted Transformers	(1 day 1 trip minimum)
5.	480 Volt Motor Control Centers	(1 day 1 trip minimum)

B. The cost of training programs to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

C. Provide detailed O&M manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

D. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance including trouble-shooting of each system.

E. All training sessions shall be videotaped by the manufacturer. Videotaping shall be high quality digital video and audio. Six (6) copies of each training session shall be provided to the Owner.

F. All training schedules shall be coordinated with and at the convenience of the Owner. Shift training may be required to correspond to the Owner's working schedule. The training shall be conducted with record "as-built" drawings sufficient for a class of eight personnel.

G. Within 120 days of contract award to the Contractor, submit an overview of the proposed training plan. This overview shall include, for each course proposed:

1. An overview of the training plan.
2. Course title and objectives.
3. Prerequisite training and experience of attendees.
4. Recommended types of attendees.
5. Course Content - A topical outline.
6. Course Duration.
7. Course Location - Training center or jobsite.
8. Course Format - Lecture, laboratory demonstration, etc.

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9. Schedule of training courses including dates, duration and locations of each class.

10. Resumes of the instructors who will actually implement the plan.

H. The Engineer will review the training plan submittal with the Owner.

3.06 POWER SYSTEM STUDY

A. Provide a complete system short circuit and selective coordination study as specified herein.

END OF SECTION

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SECTION 16110

RACEWAYS, BOXES, FITTINGS AND SUPPORTS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete raceway systems as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Refer to Section 16600 for additional requirements.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, the manufacturers' names and product designation or catalog numbers with cut-sheets of all materials specified. Indicate in the submittal, the areas where specific materials are used.

PART 2 PRODUCTS

2.01 MATERIALS

A. Rigid Aluminum Conduit

1. Rigid aluminum conduit shall be 6063 alloy and shall be as manufactured by New Jersey Aluminum Corp.; Reynolds Aluminum International Services Inc.; Alumax Extrusions, Inc; VAW of America, Inc. or equal.

2. Rigid aluminum conduit shall be for use under the provisions of NEC Article 344.

B. Electrical Metallic Tubing

1. Electrical metallic tubing shall be hot-dipped galvanized steel as manufactured by the Allied Tube and Conduit Corp.; Triangle PWC Inc.; Wheatland Tube Co.; Bridgeport or equal.

2. Electrical metallic tubing shall be for use under the provisions of NEC Article 358 but shall only be utilized in the areas permitted per paragraph 3.01.

C. Rigid Nonmetallic Conduit

1. PVC conduit shall be rigid polyvinyl chloride schedule 80 as manufactured by Carlon; An Indian Head Co.; Cantex; Queen City Plastics or equal.

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2. PVC conduit used in underground concrete encased duct banks shall be rigid polyvinyl chloride Schedule 40 as manufactured by Carlon; An Indian Head Co.; Cantex; Queen City Plastics or equal.

3. PVC conduit shall be for use under the provisions of NEC Article 352.

D. Liquidtight Flexible Metal Conduit, Couplings and Fittings

1. Liquidtight flexible metal conduit shall be Sealtite, Type UA, manufactured by the Anaconda Metal Hose Div.; Anaconda American Brass Co.; American Flexible Conduit Co., Inc.; Universal Metal Hose Co. or equal.

2. Fittings used with liquidtight flexible metal conduit shall be of the 3-piece screw-in type malleable iron as manufactured by the O.Z. Gedney Co. or equal.

3. Liquidtight flexible metal conduit shall be for use under the provisions of NEC Article 350.

E. Flexible Metallic Tubing

1. Flexible metallic tubing shall be for use under the provisions of NEC Article 348.

2. Flexible metallic tubing shall be hot-dipped galvanized steel strips shaped into interlocking convolutions firmly joined to one another assuring a complete lock similar to Tri-steel as manufactured by Triangle - PWC, Inc. or equal.

3. Flexible metallic tubing shall be used only indoors for connection to lighting fixtures in NEMA 1 administration and office areas.

4. Furnish and install insulated bushings at terminations for conductor protection.

F. Flexible Couplings

1. Flexible couplings shall be type ECGJH as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Killark Electric Manufacturing Co. or equal.

G. Boxes and Fittings

1. Pressed steel switch and outlet boxes shall be hot-dipped galvanized with hot-dipped galvanized tile rings as manufactured by the Raco Manufacturing Co.; Adalet Co.; O.Z. Manufacturing Co. or equal.

2. NEMA 1 and NEMA 12, junction boxes, pull boxes etc., shall be sheet steel unless otherwise shown on the Drawings. Boxes shall be galvanized and have continuously welded seams. Welds shall be ground smooth and galvanized. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Covers shall be gasketed and fastened with stainless steel screws. Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets (refer to Section 16191 for additional

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requirements). Boxes shall be as manufactured by Hoffman Engineering Co.; Lee Products Co.; ASCO Electrical Products Co., Inc., or equal. All boxes shall be shop primed and painted by the box manufacturer.

3. NEMA 4X stainless steel, junction boxes and pull boxes shall be 316 stainless steel with 316 stainless steel hardware and gasketed covers. Boxes shall have continuously welded seams and welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Covers shall be gasketed and fastened with stainless steel screws. Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets (refer to Section 16191 for additional requirements.) Boxes shall be as manufactured by Hoffman Engineering Co.; Lee Products Co.; ASCO Electrical Products Co., Inc., or equal.

4. Explosion-proof boxes shall be designed for Class 1, Group D, Division 1 hazardous locations. They shall be cast aluminum, with stainless steel hinged covers and stainless steel hardware and bolts; Type EJB-N4 as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Adalet-PLM or equal.

5. Cast aluminum boxes and fittings shall be copper free aluminum with cast aluminum covers and stainless steel screws as manufactured by the Killark Electric Co..; Crouse-Hinds Co.; Appleton Electric Co.; or equal.

6. Cast aluminum device boxes shall be Type FD. All cast aluminum boxes and fittings shall be copper-free aluminum with cast aluminum covers and stainless steel screws as manufactured by the Killark Electric Co.; Crouse-Hinds Co.; L. E. Mason Co. or equal.

7. Cast aluminum fittings (C's, T's, LB's, etc.) shall be of the mogul design (with rollers) as manufactured by Appleton Electric Co.

8. Conduit hubs shall be of the grounding type as manufactured by Myers Electric Products, Inc. or equal.

9. Conduit wall seals for new concrete walls below grade shall be O.Z./Gedney Co., Type WSK; Spring City Electrical Manufacturing Co., Type WDP or equal.

10. Conduit wall seals for cored holes shall be Type CSML as manufactured by the O.Z./Gedney Co. or equal.

11. Conduit wall and floor seals for sleeved openings shall be Type CSMI as manufactured by the O.Z./Gedney Co. or equal.

12. Combination expansion-deflection fittings embedded in concrete shall be Type XD as manufactured by the Crouse-Hinds Co.; O.Z./Gedney Co.; Spring City Electrical Mfg. Co. or equal.

13. Combination expansion-deflection fittings installed exposed shall be Type XJ as manufactured by Crouse-Hinds Co.; O.Z. Gedney Co.; Spring City Electrical Mfg. Co. or equal.

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14. Explosion proof fittings shall be as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; O.Z./Gedney Co. or equal.

15. Conduit sealing bushings shall be O.Z./Gedney, Type CSB or equal.

16. Elbows and couplings shall be aluminum.

17. Electrical metallic tubing fittings shall be of the steel, raintight, concrete-tight, insulated throat (connectors), compression type as manufactured by the Appleton Electric Co.; Crouse-Hinds Co. or equal.

H. Conduit Mounting Equipment

1. In dry indoor non-process areas, hangers, rods, backplates, beam clamps, channel, fasteners, anchors, nuts, washers, etc., shall be aluminum.

2. 316 Stainless steel channel with 316 stainless steel hardware (hangers, rods, backplates, beam clamps, fasteners, anchors, nuts, washers, etc.) shall be used in process areas, below grade areas, areas considered "WET", "DAMP" and "CORROSIVE" and in all outdoor locations. All channel and hardware shall be resistant to the chemicals present in the area in which it is used.

3. Expansion anchors (minimum 3/8" diameter) shall be equal to Kwik-Bolt as manufactured by the McCullock Industries, Minneapolis, MI; Wej-it by Wej-it Expansion Products, Inc., Bloomfield, CO; or Kwik-Bolt II as manufactured by the Hilti Fastening Systems, Inc, Tulsa, OK. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1-in behind the steel reinforcement. Apply anti-seize compound to all nuts and bolts. Supports installed without the approved compound shall be dismantled and correctly installed, at no cost to the Owner.

I. Wall and Floor Slab Opening Seals

1. Wall and floor slab openings shall be sealed with "FLAME-SAFE" as manufactured by the Thomas & Betts Corp.; Pro Set Systems; Neer Mfg. Co.; Specified Technologies, Inc. or equal.

PART 3 EXECUTION

3.01 RACEWAY APPLICATIONS

A. Except where otherwise shown on the Drawings, or specified, all wiring shall be in rigid aluminum conduit.

B. Rigid aluminum conduit shall be used at all locations (underground and within structures) as raceways for shielded process instrumentation wiring, shielded control wiring, data highway wiring and I/O wiring.

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C. Schedule 80 PVC conduit shall be used where shown on the Drawings and in all chemical rooms and buildings.

D. Rigid aluminum conduit or Schedule 80 PVC shall be used underground where concrete encasement is not called for or as specified in Paragraph 3.01B above. Where schedule 80 PVC is used all elbows shall be rigid aluminum.

E. PVC Schedule 40 conduit shall be used for concrete encased underground duct banks except as specified in Paragraph 3.01B above and except as specified in Section 16600.

F. Electrical metallic tubing and fittings may be used only in NEMA 1 administration and office areas. Electrical metallic tubing and fittings shall not be embedded in concrete, installed outdoors, in process areas, shops, maintenance areas, electrical rooms, etc.

G. All conduit of a given type shall be the product of one manufacturer.

3.02 BOX APPLICATIONS

A. Unless otherwise specified herein or shown on the Drawings, all boxes shall be metal.

B. Exposed switch, receptacle and lighting outlet boxes and condulet fittings shall be cast aluminum.

C. Concealed switch, receptacle and lighting outlet boxes shall be pressed steel. Welded seamed boxes will not be permitted.

D. Terminal boxes, junction boxes and pull boxes shall have NEMA ratings suitable for the location in which they are installed, as specified in Section 16000.

3.03 FITTINGS APPLICATIONS

A. Combination expansion-deflection fittings shall be used where conduits cross structure expansion joints. Refer to Structural Drawings for expansion joint locations. Provide bonding jumpers around fittings.

B. Conduit wall seals shall be used where underground conduits penetrate walls or at other locations shown on the Drawings.

C. Conduit sealing bushings shall be used to seal conduit ends exposed to the weather and at other locations shown on the Drawings.

3.04 INSTALLATION

A. No conduit smaller than 3/4 inch electrical trade size shall be used, nor shall any have more than the equivalent of three 90 degree bends in any one run. Pull boxes shall be provided as required or directed.

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B. No wire shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail.

C. The ends of all conduits shall be tightly plugged to exclude dust and moisture during construction.

D. Conduit supports, other than for underground raceways, shall be spaced at intervals of 8-ft or less, as required to obtain rigid construction.

E. Single conduits shall be supported by means of aluminum one-hole pipe clamps in combination with aluminum one-screw back plates, to raise conduits from the surface. Multiple runs of conduits shall be supported on trapeze type hangers with steel horizontal members and threaded hanger rods. The rods shall be not less than 3/8-in diameter. Surface mounted panel boxes, junction boxes, conduit, etc, shall be supported by spacers to provide a minimum of 1/2-in clearance between wall and equipment.

F. Conduit hangers shall be attached to structural steel by means of beam or channel clamps. Where attached to concrete surfaces, concrete expansion anchors shall be provided.

G. All conduits on exposed work, within partitions and above suspended ceilings, shall be run at right angles to and parallel with the surrounding wall and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. All conduit shall be run perfectly straight and true.

H. Conduit terminating in pressed steel boxes shall have double locknuts (aluminum) and insulated grounding bushings.

I. Conduit terminating in gasketed enclosures shall be terminated with grounding type conduit hubs.

J. Conduits containing equipment grounding conductors and terminating in sheet steel boxes shall have insulated throat grounding bushings with lay-in type lugs.

K. Conduits shall be installed using threaded fittings unless otherwise specified herein.

L. Liquidtight flexible metal conduit shall be used for all motor terminations, the primary and secondary of transformers, generator terminations and other equipment where vibration is present.

M. Flexible couplings shall be used in hazardous locations for all motor terminations and other equipment where vibration is present.

N. Aluminum fittings and boxes shall be used with aluminum conduit. Aluminum conduit shall not be imbedded in concrete containing chlorides, unwashed beach sand, sea water, or coral bearing aggregates. Aluminum conduit shall be isolated from other metals with heat shrink tubing (Raychem or equal) or plastic-coated hangers. Strap wrenches shall be used for tightening aluminum conduit. Pipe wrenches, channel locks, chain wrenches, pliers, etc. shall not be used.

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O. All threads on aluminum conduit and fittings shall be cleaned and coated with "No-Oxide" compound before installing.

P. Aluminum conduit installed in concrete or below grade shall be completely covered with two (2) coats of bitumastic paint or with heat shrink tubing (Raychem or equal).

Q. Where conduits pass through openings in walls or floor slabs, the remaining openings shall be sealed against the passage of flame and smoke.

R. PVC conduit to non-metallic and metallic box connections shall be made with sealing rings, with a stainless steel retainer as manufactured by Thomas & Betts Co.

S. Conduit ends exposed to the weather shall be sealed with conduit sealing bushings.

T. Expansion fittings shall be used on exposed runs of PVC conduit where required for thermal expansion. Installation and number of fittings shall be as provided per the NEC and approved by the PVC conduit manufacturer.

U. All conduit entering or leaving a motor control center, switchboard or other multiple compartment enclosure shall be stubbed up into the bottom horizontal wireway or other manufacturer designated area, directly below the vertical section in which the conductors are to be terminated.

V. Conduit sealing and drain fittings shall be installed in areas designated as NEMA 7.

W. Spare conduits and conduit stubouts for future construction shall be provided with threaded PVC end caps at each end.

X. No unbroken run shall exceed 300 feet in length. This length shall be reduced by 75 feet for each 90 degree elbow.

Y. Aluminum or rigid steel conduit entering manholes and below grade pull boxes shall be terminated with grounding type bushings and connected to a 3/4" x 10' rod with a #6 bare copper wire.

Z. Underground circuits shall be installed directly to the respective motor control centers, lighting panels, etc., except stainless steel pull boxes shall be wall mounted on structures to eliminate excessive bends. With prior written approval, below grade pull boxes may be used. Splices shall not be made in above or below grade pull boxes unless otherwise indicated on the plans and approved in writing by the Engineer.

AA. All conduits shall have a 4-inch concrete housekeeping pad at all slab and grade penetrations. The housekeeping pad shall have 45 degree, 3/4-inch chamfer at all exposed edges.

BB. All risers from underground, concrete pads, floors, etc. shall be provided with heat shrink tubing (Raychem Co. or equal) from a point 1 foot-0-inch below bottom of slab or grade to a point not less than 6 inches above grade or surface of slab.

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CC. Existing conduits are to be reused only where specifically noted on the drawings. Mandrels shall be pulled through all existing conduits which will be reused and through all new conduits 2-in in diameter and larger prior to installing conductors.

DD. 3/16-in polypropylene pull lines shall be installed in all new conduits noted as spares or designated for future equipment.

EE. Where no size is indicated for junction boxes, pull boxes or terminal cabinets, they shall be sized in accordance with the requirements of NEC Article 314.

FF. Conduits shall not cross pipe shafts, access hatches or vent duct openings. They shall be routed to avoid such present or future openings in floor or ceiling construction.

GG. The use of running threads is prohibited. Where such threads are necessary, a 3-piece cast aluminum union shall be used.

HH. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc, shall be sealed with "Duxseal" as manufactured by Manville or seal fitting to prevent the accumulation of condensation.

II. All underground control and instrumentation conduits shall be separated from power conduits by a minimum of 12 inches unless specifically noted otherwise. Crossing of control and instrumentation conduits with power conduits shall be kept to a minimum and where they must cross they shall cross at 90 degree angles.

END OF SECTION

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SECTION 16120

WIRES AND CABLES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, install and test all wire, cable and appurtenances as shown on the Drawings and as specified herein.

B. Install data highway, fiber optic, coaxial and I/O cables furnished under Division 13.

1.02 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, samples of proposed wire. Each sample shall have the size, type of insulation and voltage stenciled on the jacket.

B. Approved samples will be sent to the project location for comparison by the Resident Engineer with the wire actually installed.

C. Installed unapproved wire shall be removed and replaced at no additional cost to the Owner.

1.03 DELIVERY, STORAGE AND HANDLING

A. Carefully handle all conductors to avoid kinks and damage to insulation.

PART 2 PRODUCTS

2.01 GENERAL

A. Wires and cables shall be of annealed, 98 percent conductivity, soft drawn copper.

B. All conductors shall be stranded, except that lighting and receptacle wiring may be solid.

C. Except for control, signal and instrumentation circuits, wire smaller than No. 12 AWG shall not be used.

D. All wire of a given type shall be the product of a single manufacturer.

2.02 MATERIALS

A. 600 Volt or Less Wire and Cable

1. Wire for lighting, receptacles, and other circuits not exceeding 150 volts to ground shall be NEC type XHHW. Below grade and underground the wire shall be type XHHW.

2. Wire for circuits over 150 volts to ground shall be NEC type XHHW for sizes 4/0 AWG and smaller, and shall be NEC type RHW for sizes 250 MCM (kcmil) and larger.

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3. Wire for control circuits shall be #14 AWG minimum NEC type XHHW stranded.

4. Equipment grounding conductors shall be installed in all raceways. Conductors shall be NEC type THW, green and sized per NEC Table 250-95. Ground grid conductors shall be uninsulated unless shown otherwise on the Drawings.

5. Types XHHW, RHW and THW wire shall be as manufactured by the Southwire Co., Pirelli Cable Corp., Okonite Co., or equal.

6. Multi-conductor control cable shall be stranded, #14 AWG, 600 V, cross-linked polyethylene insulated w/PVC jacket. Type "XLP" as manufactured by the Southwire Co., American Insulated Wire Corp., or equal.

7. Telephone cable shall be #22 AWG, 4-pairs, solid copper PVC insulation and PVC jacket. UL rated Type CMR as manufactured by American Insulated Wire Corp., or equal.

2.03 INSTRUMENTATION WIRE

A. Process instrumentation wire shall be twisted pair, 600 V, cross linked polyethylene insulated, aluminum tape shielded, polyvinyl chloride jacketed type "XLP" as manufactured by the Rockbestos Co., or equal.

B. Cable for 4-20 mA instrumentation, potentiometer, RTD and similar analog circuits shall be multi-conductor twisted and shielded.

1. Single pair cable:

a. Conductors: 2 No. 16 AWG stranded and twisted

b. Insulation: XLP

c. Shield: 100 percent tape with drain wire

d. Jacket: PVC with UL and manufacturers identification

2. Three conductor (triad) cable:

a. Conductors: 3 No. 16 AWG stranded and twisted

b. Insulation: XLP

c. Shield: 100 percent tape with drain wire

d. Jacket: PVC with UL and manufacturer=s identification

3. Multiple pair cables (where shown on the Drawings):

a. Conductor: Multiple 2 No. 16 AWG stranded and twisted

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b. Insulation: XLP

c. Shield: Individual pairs and overall shielded with 100 percent tape and drain wire

d. Jacket: PVC with UL manufacturer's identification

2.04 TERMINATIONS AND SPLICES (POWER CONDUCTORS)

A. Unless otherwise indicated on the plans, no splices may be made in the cables without prior written approval of the Engineer. Where splicing is approved, then splicing material shall be approved by the Engineer and cable manufacturer. Splicing materials for all 600 volt splices shall be made with long barrel tin plated copper compression (hydraulically pressed) connectors and insulated with heavy wall heat shrinkable tubing. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.

B. 600 volt wire lugs shall be tin plated copper, long barrel compression type (hydraulically pressed) for wire sizes No. 8 AWG and larger. Lugs for No. 10 AWG and smaller wire shall be locking spade type with insulated sleeve. Lugs shall be as manufactured by the Thomas and Betts Co., or equal.

2.05 TERMINATION AND SPLICES (CONTROL CONDUCTORS)

A. Unless otherwise indicated on the plans, no splices may be made in the cables without prior written approval of the Engineer. Where splicing is approved, then splicing material shall be approved by the Engineer and cable manufacturer. Splicing materials and installation shall be as required by the Engineer. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.

B. Termination connectors shall be of the expanded vinyl insulated locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

2.06 TERMINATIONS (INSTRUMENTATION CABLES)

A. Termination connectors shall be of the expanded vinyl insulated locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

2.07 MOTOR CONNECTIONS

A. For wire sizes #8 AWG and larger, long barrel tin plated copper compression (hydraulically pressed) type connections (Bundy Co., or equal) shall be installed on the branch circuit wires and the motor leads. Bolted connections shall utilize products which are rated for vibration applications (bolt, nut and spring washer). All connections shall be insulated with heavy duty heat shrinkable material (Raychem Corp. or equal).

2.08 WIRE AND CABLE MARKERS

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A. Wire and cable markers shall be type written, heat shrinkable type as manufactured by the W.H. Brady Co., Thomas & Betts Co., 3M Co., or equal.

B. Wire and cables with diameters exceeding the capacity of the heat shrinkable markers shall be marked with pre-printed, self-adhesive vinyl tapes as manufactured by the W.H. Brady Co., Panduit Corp., or equal.

2.09 WALL AND FLOOR SLAB OPENING SEALS

A. Wall and floor slab openings shall be sealed with "FLAME-SAFE" as manufactured by the Thomas & Betts Corp. or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Uniquely identify all wires, cables and each conductor at each end with wire and cable markers.

B. Uniquely identify all wires, cables and each conductor at all pull boxes, manholes, handholes, etc. Labeling shall include circuit numbering, destination and origination, etc. Cable tags shall be embossed lamcoid secured with heavy duty tie wraps.

C. Use lubrications to facilitate wire pulling. Pulling compound shall be nontoxic, nonflammable, noncombustible and noncorrosive. The material shall be UL listed and compatible with the cable insulation and jacket.

D. All wire and cable shall be continuous and without splices between points of connection to equipment terminals, except a splice will be permitted by the Engineer if the length required between the points of connection exceeds the greatest standard shipping length available from the manufacturer specified or approved by the Engineer as the manufacturer of the particular item or wire and cable.

E. Seal openings in slabs and walls through which wires and cables pass.

F. Steel fish tapes and/or steel pulling cables shall not be used in PVC conduit runs.

G. Pull cable from direction that requires the least tension.

H. Feed cable into raceway with zero tension and without cable crossover at raceway entrance.

I. Use a feed-in tube and sheave designed for cable installation. Use sheaves with radii that exceed the cable manufacturer's recommended minimum bending radius.

J. Use a dynamometer and constant velocity power pulling. Velocity should not be less than 15-ft./min or more than 50-ft/min. Do not exceed the cable manufacturer's maximum recommended tension.

K. If cable cannot be terminated immediately after installation install heat shrinkable end caps.

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L. Fireproof exposed cables in manholes, vaults, pullboxes, switchgear and other areas not protected by conduit where medium voltage cables are present. Use fire-proofing tape and glass tape in accordance with the manufacturer's instructions. Fire-proofing tape shall be with one half-lapped layer of Scotch Brand 77 Electric Arc and Fireproofing Tape by 3M Corp. or equal. Tape shall be secured with a two-layer band of Scotch Brand 69 Glass Electrical Tape by 3M Corp. or equal over the last wrap.

M. Uniquely identify all cable at supply and receiving ends and in all manholes, handholes or pullboxes. Use embossed brass tags and tywrap fasteners.

N. Hydraulically or manually operated cable benders shall not be used unless approved in writing by the Engineer.

O. Instrumentation cables shall be installed in rigid steel conduits as specified. All circuits shall be installed as twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required.

P. Install shielded instrumentation wire from terminal to terminal with no splicing at any intermediate point. Shielded instrumentation wire, coaxial, data highway, I/O and fiberoptic cables shall be run without splices between instruments, terminal boxes, or panels.

Q. Terminal blocks shall be provided at all instrument cable junctions, and all circuits shall be identified at such junctions.

R. Ground shielding on instrumentation wire at one end only as recommended by the instrument manufacturer and isolated at all other locations. Terminal blocks shall be provided for inter-connecting shield drain wires at all junction boxes. Where individual circuit shielding is required, each shield circuit shall be provided with its own terminal block.

S. Install shielded instrumentation wire in conduit and pull boxes that contain only shielded instrumentation wire. Instrumentation cables shall be separated from all other (i.e. power, control, etc.) cables in manholes.

T. All shielded cable terminations at each end shall be provided with heat shrinkable tubing placed over the exposed shield and conductors. The tubing shall extend 1" minimum over the jacket end and extend 2" minimum from the jacket end over the exposed conductors.

3.02 WIRE COLOR CODE

A. All wire shall be color coded or coded using electrical tape in sizes where colored insulation is not available. Where tape is used as the identification system, it shall be applied in all junction boxes, manholes and other accessible intermediate locations as well as at each termination.

B. The following coding shall be used:

System	Wire	Color
240/120 Volts	Neutral	White
Single-Phase, 3 Wire	Line 1	Black

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	Line 2	Red
208Y/120, Volts 3 Phase, 4 Wire	Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts 3 Phase, 4 Wire delta, center tap ground on phase coil A-C	Neutral Phase A Phase B (High) Phase C	White Black Orange Blue
480Y/277 Volts 3 Phase, 4 Wire	Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Control (Individual Conductors)	AC DC	Red Blue

3.03 FIELD TESTING

A. Test all 600 volt wire insulation with a megohm meter after installation and prior to termination. Make tests at not less than 1000 volts DC. Submit a written test report of the results to the Engineer. Notify Engineer in writing 48 hours prior to testing.

B. Field testing and commissioning shall be done in accordance with the latest revision of the "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" published by the InterNational Electrical Testing Association (NETA Standard ATS-2009) unless otherwise modified by this Section. Minimum wire insulation resistance shall not be less than 250 Megohms.

C. All service conductors shall be tested as in paragraph A above with the Engineer present.

END OF SECTION

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SECTION 16150

MOTORS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. All motors shall be furnished as called for in other Sections of these Specifications and shall be in conformance with the requirements of this section.

1.02 QUALIFICATIONS

A. Routine tests shall be performed on representative motors, and shall include the information described on NEMA MG1-12.54 "Report of Test Form for Routine Tests on Induction Motors". Efficiency shall be determined in accordance with IEEE Publication No. 112, Method B. Power factor shall be measured on representative motors.

1.03 SUBMITTALS

A. Submittal of motor data for acceptance shall include complete nameplate data and test characteristics in accordance with NEMA Standard MG1-12.54 "Report of Test Form for Routine Tests on Induction Motors" and, in addition, the following for motors typical of the units furnished:

1. Efficiency at ½, ¾ and full load
2. Power factor at ½, ¾ and full load
3. Motor outline, dimensions and weight
4. Descriptive bulletins, including full description of insulation system
5. Bearing design data
6. Special features (i.e., space heaters, temperature detectors, etc.)
7. Power factor correction capacitor rating and type.

B. The motor Manufacturer shall submit to the Engineer as provided in Section 01300, certified dimension prints showing nameplate data and outline dimensions within three weeks of the date they receive the order.

C. Guarantee: All equipment furnished and installed under this Section shall be guaranteed against defects of workmanship, materials and proper installation for a period of one (1) year from date of acceptance. All such equipment or parts proven defective, due to the above noted causes, shall be replaced in the machines by the Contractor at no expense to the Owner.

D. Provide equipment warranty in accordance with Section 01740.

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1.04 REFERENCE STANDARDS

A. Institute of Electrical and Electronics Engineers (IEEE)

B. National Electrical Manufacturers Association (NEMA)

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

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise noted, motors below 250 horsepower shall be of the low voltage type. Unless otherwise noted, all motors ½ through 100 horsepower shall be rated 230/460 volt, 3 phase, 60 Hertz A.C.; motors 125 horsepower through 250 horsepower shall be rated 460 volt, 3-phase, 60 Hertz, and motors below ½ horsepower shall be rated 115/230 volt, 1 phase, 60 Hertz A.C.

B. All motors used with variable frequency drives shall be rated for inverter duty and shall be in accordance with NEMA MG1-2003, Part 31.

C. All motors shall be built in accordance with current NEMA, IEEE, ANSI and AFBMA standards. Motors shall be of the type and quality described by this Section and other Divisions of the Specifications, and/or as shown on the Drawings, fully capable of performing in accordance with Manufacturer's nameplate rating, and free from defective material and workmanship.

2.02 RATINGS

A. All motors shall be sufficient size for the duty to be performed and shall not exceed their full-rated load when the driven equipment is operating at specified capacity and over the operational range. Unless otherwise noted, motors driving pumps, blowers, etc. shall not be overloaded at any head or discharge condition. The motor shall not be required to deliver more than its rated nameplate horsepower, at the 1.0 service factor, under any condition of mechanical or hydraulic loading (i.e. although a 1.15 service factor is required, it may not be used under any condition).

B. Each motor shall develop ample torque for its required service throughout its acceleration range at a voltage 10 percent below nameplate rating. Where shown on the Electrical Drawings to be operated on a reduced voltage starter, the motor shall develop ample torque under the conditions imposed by the reduced voltage starting method.

C. All motors shall be continuous time rated suitable for operation in a 40 degrees C ambient unless noted otherwise.

D. Specific motor data such as Hp, rpm, etc., is specified under the detailed specification for the equipment with which the motor is supplied.

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2.03 NAMEPLATES

A. The motor Manufacturer's nameplates shall be engraved or embossed on stainless steel and fastened to the motor frame with stainless steel screws or drive pins. Nameplates shall indicate clearly all of the items of information enumerated in NEMA Standard MGI-10.38 or MGI-20.60, as applicable.

2.04 CONDENSATION HEATERS

A. Condensation heaters, where specified herein or under the detailed mechanical specifications shall be of the cartridge or flexible wrap around type installed within the motor enclosure adjacent to core iron. Heaters shall be rated for 120 Volt, single phase with wattage as required. The heater wattage and voltage shall be embossed on the motor nameplate.

2.05 WINDING TEMPERATURE DETECTORS

A. Winding temperature detectors, unless specified otherwise herein shall be a factory installed, embedded, bi-metallic switch type with leads terminating in the main conduit box. This device shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure. The switch shall have normally open contacts. Not less than three detectors shall be furnished with each motor.

B. All motors operating with variable frequency drives shall be equipped with winding temperature detectors.

2.06 POWER FACTOR CORRECTION CAPACITORS

A. The operating power factor of the motors shall range from 93 to 95 percent at full load and 95 to 98 percent when partially loaded. The capacitor current shall not exceed the motor no-load magnetizing current.

B. Capacitors shall be oil insulated or dry type (600 volt capacitors shall be of the dry type) with three high interrupting capacity current limiting integral fuse protection, blown fuse indicators, and discharge resistor and shall be hermetically sealed in steel enclosures. The insulating medium shall be nonflammable and meet the U.S. Environmental Protection Agency Standards. Covers shall be gasketed, bolt-on type. Capacitors shall be UL listed and NEMA rated and tested. Oil insulated type shall be non-PCB dielectric, biodegradable and low toxicity.

C. Units shall be designed to provide power factor correction in applications subject to the effects of harmonics as required for each installation. Where required, units shall consist of power factor correction capacitors as specified above and equipped with series inductors. The units shall be tuned to just below the 5th harmonic frequency on systems with predominately 3 Phase loads. Inductors shall have low flux density and distributed gaps, copper windings, brazed connections, winding varnish impregnated and baked, Class 220 degrees C insulation with 80 degrees C rise.

2.07 THREE PHASE INDUCTION MOTORS

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A. Motors 50 horsepower and larger shall have a 120-volt space heater for moisture control.

B. Unless specifically noted in other Sections of these Specifications, all motors shall have minimum efficiencies as listed below:

Horsepower	NEMA Nominal Efficiency, %
1-2	84.0
3-5	88.5
7-1/2	89.5
10	90.2
15	91.0
20	92.0
25	92.2
30	92.4
40-50	94.0
60-100	94.5
Over 100	95.0

C. All motors 100 horsepower and larger shall be furnished with power factor correction capacitors located in the motor starter enclosure as outlined in Sections 16480. The motor Manufacturer shall provide suitable capacitors to the motor control center Manufacturer unless otherwise noted. Power factor correction capacitors shall be provided only for the high-speed winding on a 2-speed motor. Power factor correction capacitors shall not be required for motors operating on variable frequency drives.

2.08 CONSTRUCTION

A. General:

1. All drip-proof and weather protected Type I and Type II motors shall have epoxy encapsulated windings. Totally enclosed motors shall be provided with an upgraded insulation by additional dips and bakes to increase moisture resistance and shall not be encapsulated. Motors for outdoor service shall have vacuum pressure impregnated (VPI) epoxy insulation for moisture resistance. Two speed motors shall be of the two winding type.

2. Squirrel-cage rotors shall be made from high-grade steel laminations adequately fastened together and to the shaft, or shall be cast aluminum or bar-type construction with brazed end rings.

3. All motors shall be of the premium efficiency and high power factor type. All motors shall be the corrosion resistant type conforming to motors designated as “Corro-Duty” by U.S. Motors or equal.

4. Vertical motors shall be hollow or solid shaft as required by the equipment furnished under other Sections of these Specifications.

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5. Totally enclosed non-ventilated (TENV) motors shall include the same ratings and accessories as specified for TEFC motors. Explosion-proof motors shall be UL listed and FM approved for Class 1, Division 1 hazardous areas.

B. Low Voltage, Three Phase Motors:

1. Motors shall be of the squirrel-cage induction type. Horizontal, vertical solid shaft, vertical hollow shaft, normal thrust and high thrust types shall be furnished as called for on the Drawings and as specified in other Sections of these specifications. Motors shall be of the type and quality described by these Specifications, and/or as shown on the schedule on the Drawings, fully capable of performing in accordance with Manufacturer's nameplate rating, and free from defective material and workmanship.

2. Motors shall have normal or high starting torque (as required), low starting current (not to exceed 650 percent full load current), and low slip.

3. Unless otherwise specified, motors shall be totally enclosed fan-cooled construction with a 1.15 service factor at the Class B Temperature-Rise.

4. The output shaft shall be suitable for direct connection or belt drive as required.

5. Motors shall have a Class F non-hygroscopic insulation system but shall be limited to Class B Temperature-Rise, at 1.15 service factor.

6. All motors shall have a final coating of chemical resistant corrosion and fungus protective epoxy fortified enamel finish sprayed over red primer over all interior and exterior surfaces. Stator bore and rotor of all motors shall be epoxy coated.

7. All fittings, bolts, nuts, and screws shall be plated to resist corrosion. Bolts and nuts shall have hex heads.

8. All machine surfaces shall be coated with rust inhibiter for easy disassembly.

9. Conduit box shall be split from top to bottom and shall be capable of being rotated to four 90 degree positions. Synthetic rubber-like gaskets shall be provided between the frame and the conduit box and sealed with a non-wicking, non-hygroscopic insulating material. A frame mounted pad with drilled and tapped hole, not less than 1/4-inch diameter, shall be provided inside the conduit box for motor frame grounding. All motor conduit boxes shall be provided with the correct number of conduit openings sized as indicated on the drawings. Boxes shall be suitably sized for conductor bending and terminations.

10. Totally enclosed motors shall be provided with condensate drain hole and epoxy coated motor windings to protect against moisture.

11. Nameplates shall be stainless steel. Lifting lugs or "O" type bolts shall be supplied on all frames 254T and larger. Enclosures shall have stainless steel screens. Motors shall be protected for corrosion, fungus and insects.

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12. Low voltage, three phase motors shall be manufactured by U.S. Motors, Reliance Electric or Baldor.

13. Fractional Horsepower:

    a. Fractional horsepower motors shall be rigid, welded-steel, designed to maintain accurate alignment of motor components and provide adequate protection. End shields shall be cast iron or heavy fabricated steel. Windings shall be of varnish-insulated wire with slot insulation of polyester film, baked-on bonding treatment to make the stator winding strongly resistant to heat, aging, moisture, electrical stresses and other hazards.

    b. Motor shaft shall be made from high-grade, cold-rolled shaft steel with drive-shaft extensions carefully machined to standard NEMA dimensions for the particular drive connection.

    c. For light to moderate loading, bearings shall be quiet all-angle sleeve type with large oil reservoir that prevents leakage and permits motor operation in any position.

    d. For heavy loading, bearings shall be carefully selected precision ball bearings with extra quality, long-life grease, and large reservoir providing 10 years normal operation without re-lubrication.

14. Integral Horsepower:

    a. Motor frames and end shields shall be cast iron or heavy fabricated steel of such design and proportions as to hold all motor components rigidly in proper position and provide adequate protection for the type of enclosure employed.

    b. Windings shall be adequately insulated and securely braced to resist failure due to electrical stresses and vibrations.

    c. The shaft shall be made of high-grade machine steel or steel forging of size and design adequate to withstand the load stresses normally encountered in motors of the particular rating. Bearing journals shall be ground and polished.

    d. Rotors shall be made from high-grade steel laminations adequately fastened together, and to the shaft. Rotor squirrel-cage windings may be cast-aluminum or bar-type construction with brazed end rings.

    e. Motors shall be equipped with vacuum-degassed anti-friction bearings made to AFBMA Standards, and be of ample capacity for the motor rating. The bearing housing shall be large enough to hold sufficient lubricant to minimize the need for frequent lubrication, but facilities shall be provided for adding new lubricant and draining out old lubricant without motor disassembly. The bearing housing shall have long, tight, running fits or rotating seals to protect against the entrance of foreign matter into the bearings, or leakage of lubricant out of the bearing cavity.

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f. Bearings of high thrust motors will be locked for momentary upthrust of 30 percent downthrust. All bearings shall have a minimum B10 life rating of 5 years in accordance with AFBMA life and thrust values.

g. Vertical hollow-shaft motors will have non-reverse ratchets to prevent backspin. Non-reverse ratchets shall be suitable for duty with variable frequency drives.

C. Low Voltage, Single Phase Motors:

1. Single phase motors shall be split-phase and capacitor-start induction types rated for continuous horsepower at the rpm indicated on the drawings or as required by the specifications. Motors shall be rated 115/230 volts, 60 Hertz, single phase, open drip-proof, or totally enclosed fan cooled as indicated on the drawings or as required by the specifications, with temperature rise in accordance with NEMA Standards for Class B insulation.

2. Totally enclosed fan cooled motors shall be designed for severe-duty.

3. Motors shall have corrosion and fungus protective finish on internal and external surfaces. All fittings shall have a corrosion protective plating.

4. Mechanical characteristics shall be the same as specified for polyphase fractional horsepower motors.

PART 3 EXECUTION

3.01 INSTALLATION

A. Motor Connections: All motors shall be connected to the conduit system by means of a short section 18-inch minimum of liquid tight conduit unless otherwise indicated. For all motor connections of No. 4 AWG or larger wire size, the Contractor shall install a grounding conductor in the conduit and terminate at main conduit box and at the motor control center or variable frequency drive with approved ground lugs and clamps.

B. Low Voltage: For wire sizes #8 AWG and larger, long barrel tin-plated copper compression (hydraulically pressed) type connections (Burndy Co., or equal) shall be installed on the branch circuit wires and the motor leads. Bolted connections shall utilize products which are rated for vibration applications (bolt, nut and spring washer). All connections shall be insulated with heavy duty heat shrinkable material (Raychem Corp. or equal).

3.02 TESTS AND CHECKS

A. The following tests shall be performed on all motors after installation but before putting motors into service.

1. The Contractor shall megger (1000 volts DC) each motor winding before energizing the motor, and, if insulation resistance is found to be low, shall notify the Engineer and shall not energize the motor. The following table gives minimum acceptable insulation

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resistance in megohms at various temperatures and for various voltages with readings being taken after one (1) minute of megger test run.

Winding Temperature		Degrees Voltage		
F	C	115 V.	230 V.	460V.
37	3.9	60	108	210
50	10	32	60	120
68	20	13	26	50
86	30	5.6	11	21
104	45	2.4	4.5	8.8
122	50	1	2	3.7
140	60	0.50	0.85	1.6

2. The Contractor shall check all motors for correct clearances and alignment and for correct lubrication, and shall lubricate if required in accordance with Manufacturer's instructions. The Contractor shall check direction of rotation of all motors and reverse connections if necessary. The correction for wrong rotational direction shall be made at the motor.

3. All tests shall meet the requirements of, but not be limited to, IEEE 43, 85 and 112. Efficiency tests for IEEE 112 shall include Method B.

4. The Contractor shall provide to the Engineer a typed list of all motors 1 HP and larger listing the no load motor current and voltage and the full load current and voltage. Any phase current imbalance greater than 10% shall be reported to the Engineer.

B. Field testing and commissioning shall be done in accordance with the latest revision of the "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" published by the InterNational Electrical Testing Association (NETA Standard ATS-2009).

END OF SECTION

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SECTION 16191A
MISCELLANEOUS EQUIPMENT (For THP Pre-Selection Only)

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all miscellaneous equipment as shown on the Drawings and as specified herein.

B. This Section provides the requirements for miscellaneous equipment typically employed in a facility; however, not all components specified in this Section are necessarily utilized on this project.

1.02 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01300, detailed catalog information or drawings with sufficient detail to determine compliance with the specifications including describing electrical and physical characteristics of all equipment specified.

1.03 REFERENCE STANDARDS

A. Equipment enclosures shall have NEMA ratings suitable for the location in which they are installed, as specified in Section 16000.

PART 2 PRODUCTS

2.01 MATERIALS

A. Disconnect Switches

1. Disconnect switches shall be NEMA 4X heavy duty, quick make, quick break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle unless otherwise noted. All current carrying parts shall be copper.

2. NEMA 4X enclosures shall be stainless steel.

3. NEMA 7 enclosures shall be cast aluminum.

4. Lugs shall be copper.

5. All exterior hardware shall be stainless steel.

6. Switches shall be as manufactured by Square D or Cutler-Hammer.

B. Manual Motor Starters

1. Manual starters shall be furnished and installed for all typed of single-phase motors. Manual starters shall be non reversing, reversing or two speed type as required. NEMA sizes shall be as required for the actual horsepower of the motor furnished. Manual starters

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shall have motor overload protection in each phase. Built-in control stations shall be furnished as required or as shown on the Drawings.

2. NEMA 4X enclosures shall be stainless steel.

3. NEMA 7 enclosures shall be cast aluminum.

4. Manual motor starters shall be as manufactured by Square D or Cutler-Hammer.

C. Magnetic Motor Starters

1. Motor starters shall be 2 or 3 Pole, single or 3 Phase as required, 60 Hz, 600 Volt, magnetically operated, full voltage non reversing unless otherwise shown on the Drawings. NEMA sizes shall be as required for the horsepowers shown on the Drawings.

2. Two speed starters shall be for single or two winding motors as required by the actual motor furnished or as shown on the Drawings.

3. Each motor starter shall have a 120 Volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as required or as shown on the Drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.

4. Overload relays shall be non-adjustable and manually reset.

5. Control power transformers shall be sized for additional load where required. Transformer secondaries shall be equipped with time delay fuses.

6. Built in control stations and indicating lights shall be furnished as specified herein where shown on the Drawings.

7. NEMA 4X enclosures shall be stainless steel.

8. NEMA Type 7 enclosures shall be cast aluminum.

9. Magnetic motor starters shall be as manufactured by Square D or Cutler-Hammer.

D. Combination Magnetic Motor Starters

1. Motor starters shall be a combination motor circuit protector and contactor, 2 or 3 Pole, single or 3 Phase as required, 60 Hz, 600 Volt, magnetically operated, full voltage non reversing unless otherwise shown on the Drawings. NEMA sizes shall be as required for the horsepowers shown on the Drawings. Motor circuit protectors shall be molded case with adjustable magnetic trip only. They shall be specifically designed for use with magnetic motor starters. Motor circuit protectors shall be current limiting type, with additional current limiters if required. Combination motor starters shall be fully rated for 65,000 Amps RMS symmetrical.

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2. Two speed starters shall be for single or two winding motors as required by the actual motor furnished or as shown on the Drawings.

3. Reduced voltage starters: Auto transformers shall be closed circuit transition type, open type will not be considered. Auto transformers shall be dry type with 50, 65 and 80 percent voltage taps and over temperature protection. Timing relays shall be adjustable. Relay settings shall be approximately 75 percent of relay range. Size 5 and larger shall be provided in floor mounted enclosures. The autotransformer manufacturer shall coordinate the auto-transformer sizing with the motor to be controlled.

4. Each motor starter shall have a 120 Volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as required or as shown on the Drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.

5. Overload relays shall be non-adjustable and manually reset.

6. Control power transformers shall be sized for additional load where required. Transformer secondaries shall be equipped with time delay fuses.

7. Built in control stations and indicating lights shall be furnished as specified herein where shown on the Drawings.

8. NEMA 12 enclosures shall be factory painted steel.

9. NEMA 4X enclosures shall be stainless steel.

10. NEMA Type 7 enclosures shall be cast aluminum.

11. Combination magnetic motor starters shall be as manufactured by Square D or General Electric.

12. Size 5 and larger combination motor starters shall include surge protective devices (SPD). The SPD units shall be as specified herein.

E. Control Stations and Indicators

1. Control stations shall be heavy duty type, with full size (30.5mm) NEMA 4X or 7 operators, indicators, etc.

2. Indicators shall be full voltage and push-to-test type. Indicators located indoors shall be LED type and indicators located outdoors shall be incandescent lamp type.

3. NEMA 4X enclosures shall be stainless steel.

4. NEMA 7 enclosures shall be cast aluminum.

5. Control stations shall be by Square D or Cutler-Hammer.

F. General Purpose Dry Type Transformers

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1. Transformers shall be dry type, two winding with kVA and voltage ratings as shown on the Drawings.

2. Four full capacity taps shall be furnished, two 2 1/2 percent above and two 2 1/2 percent below rated primary voltage.

3. Maximum temperature rise shall be 80 degrees C. Windings shall be copper.

4. Transformers shall be built in accordance with ANSI C89.2 and NEMA ST 20.

5. Transformers shall be provided in NEMA 1 enclosures unless otherwise noted on the Drawings or as required by Section 16000. Where a NEMA 4X and/or stainless steel enclosure is required, the transformer shall be of the TENV type.

6. Transformers shall be furnished with hot dipped galvanized mounting hardware. Where a NEMA 4X and/or stainless steel enclosure is required, the hardware shall be 316 stainless steel.

7. Transformers shall be manufactured by Square D or Cutler-Hammer.

G. Surge Protection Devices

1. Surge Protection Devices (SPD) shall be listed in accordance with UL 1449 Third Edition and as defined by IEEE C62.41 and C62.45.

2. Surge Protection The surge protection devices (SPD) shall be mounted within the equipment enclosures. Lead lengths shall not be longer than 12 inches from the main circuit breaker. The SPD shall have minimum surge current capacity rating of 120 kA per phase. The surge protection devices shall be listed in accordance with UL 1449 Third Edition and as defined by IEEE C62.41 and C62.45. The surge protection devices shall be as manufactured by Advanced Protection Technologies (APT) or equal for the power supply voltage. Models based on voltage and phase shall be similar to the following:
   1. TE/1HP 120/240 volt, single phase
   2. TE/11HP 120 volt, single phase
   3. TE/12HP 240 volt, single phase
   4. TE/2HP 120/208 volt, three phase
   5. TE/3HP 120/240 volt, three phase
   6. TE/4HP 277/480 volt, three phase
   7. TE/5HP 480 volt, three phase

H. Wireway

1. NEMA 1 wireway shall be gasketed painted steel with stainless steel screw covers.

2. NEMA 4X wireway shall be 316 stainless steel with gasketed clamped covers.

3. NEMA 1 wireway shall be Square Duct as manufactured by the Square D Co.; NEMA 4X shall be Bulletin F 22 as manufactured by the Hoffman Engineering Co. or approved equal.

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I. Control Relays

1. Control relays shall be heavy duty machine tool type, with 10 Amp, 300 Volt convertible contacts. Number of contacts and coil voltage shall be as shown on the Drawings. General use relays shall be Square D Company, Class 8501 Type X, similar by; Cutler-Hammer, Allen Bradley Company or General Electric Company. Latching relays shall be Square D Company, Class 8501 Type X, similar by; Cutler-Hammer, Allen Bradley Company or General Electric Company.

2. Time delay relays shall be pneumatic, 600 Volt, 20 Amp contacts, with calibrated knob operated adjustment and numerical time dial. On delay and off delay types and timing ranges shall be as shown on the Drawings or as required for proper operation of the actual equipment furnished. Relays shall be Agastat Model 7012 or 7022 or approved equal.

J. Polyethylene Warning Tape

1. Warning tape shall be detectable red polyethylene film, 2 in minimum width.

2. Warning tape shall be read; “CAUTION: BURIED ELECTRIC LINE BELOW” and shall be Brady Co., Catalog No. 91601 or equal.

K. Terminal Blocks

1. Terminal blocks shall be 600 Volt, channel mounted, with tubular screw and pressure plate.

2. Terminal blocks shall be Bulletin 1492-CA1 as manufactured by the Allen Bradley Co. or approved equal.

L. JIC Boxes for GF Receptacles

1. JIC boxes shall be 6-inches x 6-inches x 4-inches aluminum continuous hinge clamp cover boxes, Hoffman Catalog Number A-606 CHAL with Type L23 stainless steel fast operating JIC clamp, or approved equal.

2. Install 1-1/2-inch bushings in bottom of box for cord and plug to pass through.

M. Corrosion Inhibitors

1. All equipment enclosures, terminal boxes, etc, located in a NEMA 4X rated area (where shown on the Drawings) that contains electrical or electronic equipment or terminal strips shall be furnished with an internally mounted, chemically treated corrosion inhibitor pad.

2. The corrosion inhibitor pads shall be as manufactured by Hoffman Engineering Co.; 3M or approved equal.

N. Disconnect & Control Station Equipment Mounting Stands

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1. Equipment mounting stands shall be custom fabricated from 1/4" 316 stainless steel plate and 3" 316 stainless steel channel, unless otherwise shown on the Drawings.

2. All hardware shall be 316 stainless steel.

O. Terminal Cabinets:

1. Interiors shall be so designed that control relays and terminal blocks can be replaced or added without disturbing adjacent units. Each cabinet shall be furnished with a minimum of 50 spare terminals.

2. All interiors shall be completely factory assembled with control relays, terminal blocks, insulating barriers, etc. All 120 volt AC and DC terminal blocks shall be isolated from each other by insulating barriers or separate enclosures.

3. All wiring within the cabinets shall be grouped together in harnesses and secured to the structure.

4. All shielded cables shall terminate in separate cabinets. A third terminal shall be provided for each twisted shielded pair and the shield for each connected thereto, unless otherwise noted on manufacturer's shop drawings.

5. Terminal blocks shall be tubular screw type with pressure plates and shall be rated 600 volts. Terminal blocks shall be Allen Bradley Catalog Number 1492 CA1 or approved equal.

6. Boxes shall be made from 14 gauge galvanized steel and shall be of sufficient size to provide a minimum of 4 inches of wiring space on all sides and between adjacent terminal blocks. A minimum 2 inch spare shall be provided between control relays. A minimum of four mounting studs shall be provided on each cabinet. Cabinets shall be furnished without knockouts. Holes for raceways shall be drilled on the job.

7. A single or double hinged door shall cover the front of each terminal cabinet. Doors shall have a neoprene gasket, vault type handle, three point catch and lock. Two keys shall be supplied for each lock. All locks shall be keyed alike. A terminal block schedule shall be provided with each terminal point numbered and identified (typewritten) as to function.

8. All exterior and interior steel surfaces of the cabinets shall be properly cleaned and finished with ANSI 61 grey over a rust inhibiting phosphatized coating conforming to ANSI A55.1. The finish paint shall be of a type to which field applied paint will adhere.

9. Cabinets in wet, damp, corrosive and all outdoor locations shall be NEMA 4X 316 stainless steel.

10. Cabinets shall be Hoffman Engineering Company with latch kit hardware or be an approved equal product.

P. Intrinsically Safe Relays

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1. Intrinsically safe relays shall be solid state type with 5 Amp output contacts, suitable for use on a 120 Volt, 60 Hz power supply and shall be FM approved for pilot devices in Class I, Division 1, Group D hazardous atmospheres.

2. Intrinsically safe relays shall be Gems Solid State Safe Pak as manufactured by Gems Sensors, Division of Transamerica Delaval, Inc. or approved equal.

Q. Power Monitors

1. Microprocessor based metering: At each circuit location shown on the Drawings, furnish a digital microprocessor based metering device capable of monitoring and displaying the functions listed below. The device shall provide the status input functions indicated and the capability to communicate data to a centralized monitoring system via a data highway network. The device shall be UL listed. The device shall be the ION 7300 Series as manufactured by Square D Company, Type EPM 7000 as manufactured by General Electric or approved equal.

2. Metering Functions
    1. The Digital AC Instrumentation Package shall be capable of measuring, calculating and directly displaying on the front panel display the following information:
        1) Volts on each phase plus average of all three phases
        2) Current on each phase plus average of all three phases
        3) Neutral or ground current
        4) Frequency
        5) Power Factor
        6) KVA
        7) KVAR
        8) KW
        9) Total KWH as an accumulating total, providing bi-directional (import/export) indication
        10) Total KVARH as an accumulating total, providing bi-directional (import/ export) indication
        11) KW Demand, user programmable length of each demand period and the number of periods matching utility billing periods.
        12) Amps Demand.

3. Monitoring and Control Functions
    1. Provide seven digital status outputs to monitor up to 61 conditions when the programmed threshholds are exceeded.
        1) Voltage Disturbances
        2) Harmonic Distortion (THD)
        3) Phase Unbalance (Voltage or Current)
        4) Demand (Current, Watts, VARS or VA)
        5) Power Factor
    2. Provide one auxiliary analog input rated 1.0 VAC/VDC nominal full scale input which can be used to measure an external variable such as transformer temperature, air temperature, or battery voltage.
    3. Provide three auxiliary analog outputs (selectable 0-20ma or 4-20ma) proportional to any measured parameter.

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4. Five (5) communication ports: Ethernet, modem, 2 x RS-485, RS-485 & front panel optical. Metering shall be adaptable to the following minimum protocols: Modbus RTU slave, Modbus TCP & DNP
5. Provide four Form C dry contact control relay outputs rated 277 VAC or 30 VDC at 10 Amp maximum load current, that can each function as:
    1) Setpoint relays that operate as a function of any measured parameter for demand, power factor, or load control. Seven programmable setpoints shall each have programmable operate and release limits and time delays on operate and release. Relays shall provide selectable pulse mode or tach mode operation.
    2) Remote control relays operated by commands via the communications port.
    3) Breaker trip relay (over/under volt, volt unbalance, phase reversal, current unbalance, over/under frequency).
    4) KWH or KVARH pulse output relay.
    5) Alarm relays.

4. Operational Features
    1. Provide the following operating features:
        1) True RMS measurements.
        2) Connect directly to PT's and CT's for systems over 600 volts.
        3) Provision for a fourth current input for measurement of ground or neutral current.
        4) Shall meet ANSI C 37.90.1 for surge protection.
        5) Display up to any seven parameters listed including a graphical display of any captured waveform.
    2. Store in non-volatile memory the following:
        1) A time-stamped alarm and event log of up to 10 events which records event date, time (to 10 Ms), event type and value for all over/under limit conditions, all status input activity and all relay operations. Log shall be read via the front panel display.
        2) A time-stamped minimum/maximum log, which records the value of any parameter exceeding the previous highest or lowest value recorded. Log shall be read from the front panel display or via communication port.
        3) All setup data.

5. The device shall be field programmable as follows:
    1. Volts scale, volts mode (wye, delta, single phase), amps scale, Vaux scale, baud rate and the relay operation shall be programmable from the front panel.
    2. All parameters above, plus additional alarm/event parameters shall be programmable via the communications port using a portable terminal or a computer.
    3. The programming shall be password protected.

6. Where multiple power monitors are shown within the same electrical gear, the Manufacturer shall provide all interfacing as required with each unit to provide a common connection/termination point.

7. All necessary communications cables and viewing software shall be provided. All software shall include licensing and be of the latest version at the time of startup.

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2.02 CONTROL PANEL CONSTRUCTION REQUIREMENTS

A. The Manufacturer shall provide a complete and fully functional control system to manually or automatically operate the control system as specified herein and in other applicable sections of these specifications. All Manufacturers recommended safety devices shall be furnished to protect operators. All control devices, unless specified otherwise, shall be mounted in the Control Panel.

B. Control Panel Construction

1. The control panel shall consist of a main circuit breaker, motor circuit protectors (MCP), magnetic starters or VFD for each motor as required by Division 11, and a 120-volt control power transformer (fused on primary and secondary). All control components shall be mounted in one common enclosure. Control switches shall provide means to operate each motor manually or automatically. Where VFD's are required, thermal magnetic circuit breakers shall be provided ahead of each VFD. All VFD speed controls, speed adjustment and speed monitoring shall be accessible from the front door. VFD's shall be as specified herein for 5 horsepower and smaller, for greater that 5 horsepower refer to specification Section 16370.

2. Unless specifically noted otherwise, the electrical control equipment shall be mounted within a NEMA 4X enclosure, constructed of not less than 14 gauge 316 stainless steel. Latches shall be quarter turn quick release type and all hardware shall be 316 stainless steel. Where NEMA 3R or 12 enclosures are specifically required, the door shall be provided with a pad-lockable vault type 3-point latch. The enclosure shall be equipped with a door and shall incorporate a removable back panel on which control components shall be mounted. Back panel shall be secured to enclosure with collar studs. Door(s) shall be interlocked with main circuit breaker and provided with pad-locking provision. When VFD's are required; NEMA 4X stainless steel side mounted air conditioning units shall be provided. A/C units shall be sized by the manufacturer to maintain suitable VFD and panel components when all VFD's are operating at 100 percent load.

3. Where control panels are required to be NEMA 7, all components shall be rated for NEMA 7 and shall be approved for use within the hazardous area in which they are installed. All NEMA 7 enclosures shall be aluminum. Viewing windows shall be provided for all level, pressure, temperature, etc. devices.

4. All motor branch circuit breakers, motor starters and control relays shall be of highest industrial quality, securely fastened to the removable back panels with screws and lock washers. Back panels shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any component.

5. A thermal-magnetic air circuit breaker, Type FH as manufactured by the Square D Company, or equal, shall be furnished for the main breaker. All circuit breakers shall be sealed by the manufacturer after calibration to prevent tampering. Each circuit breaker shall be adequately sized to meet the equipment operating conditions. Motor Circuit Protectors (MCP) shall be molded case with adjustable magnetic trip only, "Mag-Gard" as manufactured by the Square D or equal.

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6. An open frame, across-the-line, NEMA-rated magnetic motor/starter, Class 8536 as manufactured by the Square D Company, or equal, shall be furnished for each motor. All motor starters shall be provided with motor circuit protectors and equipped to provide under-voltage release and overload protection on all three phases. Motor starter contacts shall be easily replaceable without removing the motor starter from its mounted position. Overloads shall be of the melting alloy or bi-metallic type, adjustable overloads are not acceptable, Class 10 quick trip overloads shall be provided for all submersible motors. Overload reset push-buttons shall be located on the exterior of the door. Normally open and normally closed auxiliary motor overload contacts wired to terminal blocks shall be provided for each motor starter within the control panel

7. For control panels with motors sized 10 horsepower and larger, provide a selector switch (enable/disable) and field settable 0 -180 second timer. The enable/disable selector switch shall be to field select operation on generator power. The timer shall delay equipment start up after a power loss. Refer to the drawings for additional requirements.

8. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein and as required by Divisions 13, 16 and as shown on the drawings.

9. All operating control and instruments shall be securely mounted on the exterior door. All controls and instruments shall be clearly labeled to indicate function. All exterior mounted equipment shall be NEMA 4X. NEMA 7 panels shall have NEMA 7 rated door mounted devices.

10. Mode selector switches shall be Hand-Off-Auto type to permit override of automatic control and manual actuation of shutdown. Switches shall be NEMA 4X (800H) as manufactured by Allen-Bradley, or equal, providing three (3) switch positions, each of which shall be clearly labeled according to function. NEMA 7 panels shall have NEMA 7 rated door mounted switches and potentiometers.

11. Indicator lamps shall be LED full voltage type and mounted in NEMA 4X (800H) modules, as manufactured by Allen-Bradley. Lamp modules shall be equipped to operate at 120 volt input. Lamps shall be easily replaceable from the front of the control compartment door without removing lamp module from its mounted position. Indicators shall be provided for individual motor run and an indicator for each failure condition. NEMA 7 panels shall have NEMA 7 rated door mounted LED indicators.

12. A six (6) digit, nonreset elapsed time meter shall be connected to each motor starter to indicate the total running time of each motor in "hours" and "tenth of hours". The elapsed time meters shall be Series T50 as manufactured by the ENM Company or equal. NEMA 7 panels shall have NEMA 7 rated door mounted elapsed time meters or suitable NEMA 7 viewing windows.

13. A failure alarm with horn and beacon light shall be provided. Silence and reset pushbuttons shall also be furnished. A common failure reset pushbutton shall be provided to reset the alarm conditions (reset shall occur only if fault condition has been cleared). The alarm horn shall be weatherproof rated with gasket (Federal Signal Corporation, Cat. #350 or equal). The alarm beacon shall be NEMA 4X rated, red lense and solid state flasher (Ingam

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Products Inc. LRX-40). NEMA 7 panels shall have NEMA 7 rated devices of suitable quality.

14. The control panel shall operate on a power supply of 480 volts, 3-phase, 60 hertz unless otherwise noted or shown on the drawing.

15. Control panels shall be provided with a generator lockout relay controls and enable/disable selector switch. The lockout relay controls shall prevent the equipment from operating on generator power when the selector switch is in the enable position. Refer to the drawings for additional requirements.

16. The control diagrams and overload tables shall be laminated to the inside of the door except where door space is limited the laminated documents shall be in the print storage pocket.

17. Print storage pockets shall be provided on the inside of each panel. Pocket shall be of sufficient size as required to hold all prints necessary to service the equipment. A set of reduced drawings shall be provided for each panel, fixed to fit in the storage pocket.

18. The control panel shall include an adjustable time delay relay to prevent any two motors from starting simultaneously (where more than one motor of the same function is controlled from a single panel). All timing relays shall be solid state, with pin (octal) and bases, relays shall be T-series as manufactured by Diversified Electronics Inc. or equal.

19. Where more than one motor of the same function is controlled from a single panel, alternators shall be provided to sequence motors, alternators shall be 008-120-13SP or 009-120-23AP as manufactured by Sta-con, or equal.

20. A phase monitor shall be provided for the control panel, monitors shall be model SUA-440-ASA as manufactured by Diversified Electronics Inc., or equal.

21. All exterior mounted equipment shall be rated NEMA 4X. Hinged NEMA 4X 316 stainless steel viewing windows will be permitted where such equipment is not available with a NEMA 4X rating.

22. The control panel shall be provided with lightning and surge protection. The surge protection devices (SPD) shall be mounted within the control panel enclosure. Lead lengths shall not be longer than 12 inches from the main circuit breaker. The SPD shall have minimum surge current capacity rating of 120 kA per phase. The surge protection devices shall be listed in accordance with UL 1449 Third Edition and as defined by IEEE C62.41 and C62.45. The surge protection devices shall be as manufactured by Advanced Protection Technologies (APT) for the power supply voltage:
    1. TE/05XDS - 480 VAC, 3-Phase
    2. TE/04XDS - 480/277 VAC, 3-Phase
    3. TE/03XDS - 120/240 VAC, 3-Phase
    4. TE/02XDS - 120/208 VAC, 3-Phase
    5. TE/01XDS - 120/240 VAC, 1-Phase

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23. All control panel wiring shall be numbered at both ends with type written heat shrinkable wire markers.

24. Wiring shall be stranded copper, minimum size #14 AWG (except for shielded instrumentation cable), with 600 volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation.

25. The control panel shall be provided with nameplates identifying each component, selector switches, pilot lights, etc.. Nameplates shall be permanently affixed using an epoxy process (inner door nameplates shall be fastened with stainless steel screws). Nameplates shall be laminated plastic, engraved white letters with a black background.

26. All control panels shall be provided with a master nameplate located on the exterior door.

27. Where applicable provide a nameplate which reads as follows "CAUTION - THIS PANEL CONTAINS A VOLTAGE FROM AN EXTERNAL SOURCE." Letters shall be black on a high visibility yellow background.

28. Corrosion Inhibitor Emitter: Inclusion of an industrial corrosion inhibitor emitter that shall protect internal components of control panel from corrosion for up to one year. One spare emitter shall be provided for each control panel.

29. All control relays shall be have 10 amp rated contacts (minimum), 11 pin with mounting base , 3PDT (minimum), with LED indicators to show relay status, relays shall be manufactured by Potter Brumfield or equal.

30. Terminal blocks shall be 600 volt heavy duty rated, tubular clamp type. Terminal strips shall be Allen Bradley catalog #1492-CA-1 or equal. Each terminal shall be individually labeled.

31. The completed control panel assembly shall be U.L. certified.

32. Intrinsically safe relays shall be solid state type with 5 amp output contacts, suitable for use on 120 volt, 60 hertz power supply and shall be Factory Mutual approved for devices in Class 1, Division 1 hazardous atmospheres. Intrinsically safe relays shall be Gems Solid State Safe-Pak as manufactured by Gems Sensors, Division of Transamerica Delaval, Inc. or equal.

33. All electronic control equipment (i.e. controllers, isolators, signal boosters, transmitters, PLC's, etc) shall be as specified in Division 13.

34. A copper ground bar with sufficient terminals for all field and panel ground connections shall be provided.

35. All signal wiring entering and exiting the control panel shall be provided with surge protection. Surge protection shall be as specified in Division 13.

36. An 8-inch (minimum) clear space within the enclosure shall be provided horizontally along the entire top and bottom of the control panel. A 4-inch (minimum) clear space within the

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enclosure shall be provided vertically along the entire sides of the control panel. No devices, terminals, etc. shall be installed within this space, the space shall be provided for field conduit and wiring access only.

37. All wiring within the control panel shall be color coded or coded using electrical tape in sizes where colored insulation is not available. The following coding shall be used. For different system voltages, the color coding shall be as required by the Engineer.

System	Wire	Color
480Volts	Ground	Green
3 Phase	Neutral (As Required)	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
Control (Individual Conductors)		
	AC	Red
	DC	Blue
	Foreign	Yellow

C. Variable Frequency Drives

1. Where variable frequency drives are required per other divisions of these specifications, they shall conform to all control panel construction requirements and the variable frequency drive specifications herein.

2. AC Adjustable Frequency Drives: Sine coded pulse width modulated (PWM), transistorized inverter designed for use with standard induction motors up to 5 Hp, constant or variable torque as required for the load application, with current limiting input fuses, line reactors, circuit breaker disconnect, motor isolation contactor, control transformer overload relays and process signal follower card. Drives shall be UL listed.

3. Service Conditions
    1. Input power: 460 VAC, plus 10 percent, minus 5 percent, 3 Phase, 60 Hz.
    2. Input frequency: 57 to 63 Hz.
    3. Ambient temperature: 0 to 40 degrees C (Enclosed).
    4. Elevation: Up to 3300 feet above mean sea level.
    5. Relative humidity: Up to 90 percent non condensing.

4. Minimum Drive Efficiency: 95 percent or better at 4/4 motor base speed and rated torque.
    1. Efficiencies shall be based on a centrifugal load condition with current proportional to the square of the speed and shall include all control power and cooling system losses associated with the drive.

5. Displacement Power Factor: 0.95 or better at any speed, measured at drive input terminals.

6. Drive Output: 100 percent rated current continuous, suitable for operation of the driven equipment over a 30:1 speed range without overloading or low speed cogging. Drives

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shall be capable of a continuous overload up to 110 percent rated current and a maximum 150 percent overload for 1 minute. Starting torque shall be matched to the load.

7. Voltage Regulation: plus or minus 1 percent of rated value, no load to full load.

8. Output Frequency Drift: No more than plus or minus 0.5 percent from setpoint.

9. Drives shall withstand five cycle transient voltage dips of up to 15 percent of rated voltage without an under voltage trip or fault shutdown, while operating a variable torque load.

10. Drives shall be provided with input and output line reactors. Line reactor sizing shall be per manufacturer. Manufacturer shall coordinate with the contractor to obtain all relevant data for reactor sizing.

11. Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controller to any of the following conditions shall not result in component failure or the need for fuse replacement.
    1. Short circuit at controller output
    2. Ground fault at controller output
    3. Open circuit at controller output
    4. Input under voltage
    5. DC bus overvoltage
    6. Loss of input phase
    7. AC line switching transients
    8. Instantaneous overload
    9. Sustained overload exceeding 115 percent of controller rated current
    10. Over temperature responsive to a thermal switch in the motor or an overload relay

12. The controller electronics shall contain light emitting diodes (LED's) to monitor and indicate the following conditions.
    1. Under voltage
    2. Overvoltage
    3. Ground Fault
    4. Instantaneous Over current
    5. Over temperature
    6. Power UP Delay/Reset
    7. Drive Enabled
    8. Bus Capacitors Charged

13. Make provisions to accept a remote dry contact closure to start and stop the drive(s) with the drive control system in the AUTO mode.

14. Make provisions to accept a 4 20 mADC input signal for remote speed control. Input shall be isolated at the drive and active with the drive control system in the AUTO mode.

15. Provide a 4 20 mADC isolated output signal proportional to speed for remote speed indication.

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16. Provide two sets of Form C auxiliary dry contacts for remote indication of VFD running status.

17. Provide two sets of Form C auxiliary dry contacts for remote indication of VFD fault.

18. Following an over or under voltage trip, the drive shall automatically restart after a short time delay after the incoming line voltage is within the specified range.

19. Provide all relevant data to the contractor for all VFDs supplied for inclusion into the electrical system harmonics study specified in section 16370.

D. Spare Parts

1. The following number of spare parts shall be furnished for each control panel.
    1. 2 control relays for each type furnished
    2. Indicator light assembly
    3. 5 fuses for each type/size furnished
    4. 1 set thermal overloads for each size furnished
    5. 1 selector switch for each type furnished
    6. 1 starter coil for each size furnished
    7. 1 spare variable frequency drive for each size furnished

PART 3 EXECUTION

3.01 INSTALLATION

A. Mounting Stands

1. Field mounted disconnects, pushbutton control stations, etc, shall be mounted on 316 stainless steel stands as specified herein or as shown on the Drawings. Where clearance requirements for stands may not be maintained, the Engineer may direct equipment to be wall mounted adjacent to the motor or device, but in no case shall the distance from the motor or device to the control station exceed 3-ft.

END OF SECTION

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SECTION 16370

VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to manufacture, assemble, shop-test, and install variable frequency drives with integral isolation/phase shift transformers, output filters as shown on the Drawings and as specified herein. All variable frequency drives shall be provided by the pump manufacturers specified in specified in Division 11.

B. These specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the requirements of the equipment furnished. They are, however, intended to cover the furnishing, the shop testing, the delivery and complete installation and field testing, of all materials, equipment and appurtenances for the variable frequency drives herein specified.

C. The Contractor shall furnish only one manufacturer of variable frequency drives as specified herein.

D. The work shall include the services of factory representatives of the variable frequency drive manufacturers to inspect the final installation, to perform field acceptance tests on the installed equipment and to instruct the regular operating personnel in the care, operation and maintenance of equipment.

1.02 DESCRIPTION OF SYSTEMS

A. The variable frequency drives specified hereinafter will become part of a complete system as specified in Division 11. The Contractor shall coordinate with the manufacturer of the Division 11 equipment to ensure the compatibility of the equipment.

B. The variable frequency drives will operate motors as specified in Division 11 and Section 16150. The drives furnished herein under shall be totally compatible with the Motors to be supplied.

C. Additional controls shall be provided as required by Division 11 and 13 and as shown on the drawings.

1.03 QUALIFICATIONS

A. Variable speed drives shall be of sufficient size for the duty to be performed and shall not exceed their full-rated capacity when the driven equipment is operating as specified.

B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this

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requirement. The equipment furnished shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

C. All equipment furnished under these Specifications shall be new and unused and shall be the standard cataloged product of a manufacturer having a successful record of manufacturing and servicing the equipment and systems specified herein for a minimum of five (5) years.

D. The variable frequency drive manufacturer shall maintain, as part of a national network (United States), engineering service facilities within 250 miles of the project site to provide start-up service, emergency service, calls, repair work, service contracts, and maintenance and training of customer personnel. When requested by the Engineer, documentation shall be provided showing compliance, capabilities and references for this requirement.

E. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

F. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

G. Approved Manufacturers: Allen-Bradley.

1.04 SUBMITTALS

A. Copies of all materials required to establish compliance with the specifications shall be submitted. Submittals shall include at least the following:

1. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt locations. Details to also include front elevations with designation of devices and equipment on door(s) and internal to the enclosure. Internal layout of components including dimensions and space requirements. Standard preprinted sheets or drawings simply marked to indicate applicability to this contract will not be acceptable.

2. Descriptive literature, bulletins and/or catalogs of the equipment.

3. Data on the characteristics and performance of the variable frequency drives. Data shall include certification that the variable frequency drives are warranted for use with the motors specified in Division 11 and Section 16150.

4. Complete drawings shall be furnished for approval before proceeding with manufacture and shall consist of job specific master wiring diagrams, elementary or control schematics including coordination with other electrical control devices operating in conjunction with the variable frequency drive, and suitable outline drawings with sufficient details for locating conduit stub-ups and field wiring. Due to the complexity of the system, it is imperative the above drawings be clear and carefully prepared to facilitate interconnections with other equipment. Standard preprinted sheets or drawings simply marked to indicate applicability to this contract will not be acceptable.

5. The total weight of the equipment including the weight of the single largest item.

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6. A complete total bill of materials of all equipment.

7. A list of the manufacturer's recommended spare parts with the manufacturer's current price for each item.

1.05 OPERATING INSTRUCTIONS

A. The operating and maintenance manuals shall be furnished in accordance with Section 01730. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

B. A factory personnel of the manufacturer who has complete knowledge of proper operation and maintenance of the specified equipment shall provide all the instruction and training as specified herein. This shall be done in conjunction with and coordinated with the O&M instructions to be provided for the equipment, motors and control panels.

C. The cost of training programs to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the System being supplied. The manufacturer shall include the travel and expenses for two Owner personnel attending factory training.

D. The manufacturer shall provide classroom training detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project as per Section 01730.

E. The manufacturer shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to Owner.

F. The training program shall represent a comprehensive program covering all aspects of the VFD and maintenance of the system.

G. All training schedules shall be coordinated with and at the convenience of the Owner. Shift training may be required to correspond to the Owner's working schedule.

H. Factory Training: Factory training shall be conducted before System is commissioned, and subsequent to final manual submittals. Factory training shall consist of schooling and hands-on experience. The class shall be for two people and consist of four days of extensive training covering the following:

1. Theory of Operation

2. Use of Software

3. Troubleshooting and Maintenance

I. On-site Training: On-site (field) training shall be conducted at the Owner's site and shall provide detailed hands-on instruction to Owner's personnel covering: system debugging, program

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modification, trouble-shooting, maintenance procedures, calibration procedures, and system operation. The training shall run at times chosen by the Owner. The training shall be conducted over a period of five days.

1.06 TOOLS AND SPARE PARTS

A. One (1) set of all special tools required for normal operation and maintenance shall be provided.

B. The manufacturer shall furnish a complete list of recommended spare parts necessary for the first five (5) years of operation.

C. A list of the manufacturer's recommended spare parts with the manufacturer's current price guaranteed for one year for each item. The manufacturer shall include $20,000.00 (total) in his bid for spare parts to be selected by the Owner.

D. One quart of enclosure touch-up paint.

1.07 PRODUCT HANDLING

A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation.

B. All equipment and spare parts must be properly protected against any damage during a prolonged period at the site.

C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

D. Each box or package shall be properly marked to show its net weight in addition to its contents.

1.08 WARRANTY

A. All equipment supplied under this Section shall be warranted by the Contractor and the equipment manufacturers for a period of one (1) year from startup or 24 months from shipment, which ever occurs first in accordance with Section 01740.

B. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it shall be replaced and the machine(s) and the unit(s) restored to service at no additional cost to the Owner.

C. The manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.

1.09 HARMONICS STUDY

A. The VFD manufacturer shall provide an electrical system harmonics study for each electrical distribution system including utility and generator sources. The goal of the studies shall be to

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determine requirements for the variable frequency drives as required to comply with the harmonic distortion levels. The harmonic study shall include all panel mounted and motor control center mounted variable frequency drives specified in Section 16191 and Section 16480 and as indicated on the drawings.

B. The harmonics study shall verify compliance with the harmonics and line notching requirements specified herein, with information on the filter system (if necessary) required to achieve the specified levels. The study shall be based on and contain, as a minimum, the following:

1. Minimum utility system short circuit kVA (confirm in writing with utility); with all VFDs operating simultaneously, operating over a 60 to 100 percent speed range. The location point of common coupling shall be the secondary of the respective pad mounted transformer(s) or liquid filled substation transformers(s).

2. Explanation of method used to perform the study.

3. Explanation of study results with specific recommendations on filters and/or other measures that will be implemented to meet the specified limits.

4. All calculations and/or computer printouts used to arrive at the recommendations.

5. Individual drive voltage and current harmonic content up to the fiftieth harmonic, and the combined total of all the drive harmonic contents reflected in the system source supply voltage and current as a percent of the 60 Hz fundamental under actual load conditions from 0 - 60 Hz at 10 Hz increments.

C. The harmonic distortion on the total installed distribution system for voltage and current distortion levels and line notching shall meet the requirements of IEEE 519-1992. Capacitor-Inductor filter traps that require tuning to the power system are not acceptable. The Variable frequency drive manufacturer shall provide for the design, furnishing and installation of the filtering and appurtenances required to meet the requirements as specified herein. Any costs associated with provision of and installation, space, wiring, conduit, etc. for filtering equipment shall be provided at no additional cost to the Owner.

D. The manufacturer shall be responsible to provide all data necessary to perform the study. This includes feeder cable sizes, approximate feeder length motor data, switchgear data, utility data, generator data, existing field data (if required) and any other information relevant to the study.

E. The reports shall be provided prior to or with the variable frequency drive shop drawings for approval. Submittals for the variable frequency drives submitted prior to or without the study will be considered incomplete and not reviewed.

F. The variable frequency drive manufacturer is responsible to provide an up-to-date single line diagram with referenced data within the submittal for each study.

G. The study shall also address methods the manufacturer is providing to address the problems associated with “dv/dt” and “reflected waves” based on the actual installations (wire type, conduit type, lengths, etc.). The VFD Manufacturer shall provide any/all equipment necessary to address

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any of the potential problems associated with dv/dt and reflective waves at no additional cost to the Owner. The VFD Manufacturer shall include all necessary calculations and mitigation equipment with the shop drawing submittals.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall furnish and supervise installation of variable frequency drives as described in this specification and as detailed on the applicable Drawings.

B. The Contractor shall be responsible for the erection, installation, and start up of the equipment covered by this specification.

C. The variable frequency drive shall be comply with the latest applicable standards of ANSI, NEMA, IEEE, and the National Electrical Code.

D. Variable frequency drives shall operate as specified on standby generators or normal power sources.

E. Variable frequency drives shall be 6 pulse (or greater) for less than 100 HP. If greater than 6 pulse is provided for less than 100 HP, the variable frequency drives shall utilize a phase shift transformer and cancellation technique. Variable frequency drives shall utilize a phase shift transformer and 12 pulse (or greater) cancellation technique shall be provided for 100 HP and larger.

F. The variable frequency drives shall be provided with an output filters or output load reactors to reduce the transient voltage (dv/dt) at the motor terminals.

2.02 CONSTRUCTION

A. The variable frequency drives (VFD) shall be rated at 480 VAC input with features and options as specified.

B. The variable frequency drives shall be rated for the HP, full load current and rpm of the motor. The variable frequency drives shall be designed to provide microprocessor-based continuous speed adjustment of three-phase motors. The variable frequency output voltage shall provide constant volts-per-Hertz excitation for the motor up to 60 Hertz. The variable frequency drives shall be optimized for an adjustable or selectable carrier frequency to reduce motor noise. The carrier frequency shall be field adjustable and adjusted by the manufacturer's field Engineer during start up.

C. The variable frequency drives shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency output via a two-step operation. Variable frequency drives utilizing a third power section are not acceptable. Adjustable Voltage and Current Source variable frequency drives are not acceptable. Transistors shall be used in the inverter section. GTOs and SCRs are not acceptable.

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D. The variable frequency drives shall be current regulated. Variable frequency drives permitting instantaneous overcurrent trips other than an output short circuit are not acceptable.

E. The variable frequency drives shall have an efficiency that exceeds 97% at 100% speed and load. The efficiency shall exceed 90% at 50% speed and load. The variable frequency drives shall maintain the line side displacement power factor no less than .95 regardless of speed and load. Variable frequency drive efficiency shall be defined as drive output power at the motor output terminals divided by the input power at the line side of the main circuit breaker.

F. Standard operation conditions shall be:

1. Incoming power: Three phase, 480V (+10% to -10%) and 60 hertz (+/- 2 hertz) power to a fixed potential DC bus level.

2. Humidity: 0 to 95% (noncondensing).

3. Altitude: 0 to 3,300 feet above sea level.

4. Ambient temperature: 0 to 40 degrees C.

G. The variable frequency drives shall be able to start into a spinning motor. The variable frequency drives shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the variable frequency drives shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor in the preset method of starting.

H. Variable frequency drive enclosures shall be NEMA Type 1 gasketed free-standing wall or floor-mounted, force ventilated (with replaceable air filters) construction requiring front access only. Variable frequency drives requiring rear access for any maintenance are not acceptable. The cooling air required to dissipate heat generated by the power electronics shall be isolated from all drive electronics. Variable frequency drives using liquid-cooled assemblies in conjunction with associated pumps, piping, and separate remote mounted exchangers are not acceptable. The inverters and converters shall have complete unobstructed front accessibility with easily removable assemblies. The complete enclosure shall maintain a constant height, width and depth. The height for all floor-mounted enclosures shall be 90" high. The enclosures shall include the integral isolation/phase shift transformer (as required), input and output filters, and shall not exceed the space allotment shown on the drawings.

I. All variable frequency drive programmable parameters shall be adjustable from a digital operator keypad located on the front door of the variable frequency drive. Parameters shall include:

1. Programmable maximum and minimum frequency.

2. Programmable acceleration and deceleration times.

3. Selectable carrier frequencies, V/Hz, and critical frequency avoidance lockout.

4. Adjustable electronic overload and torque limits.

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5. Multiple attempt automatic restart following utility outage or fault condition.

6. Jog, thread, and preset speeds.

7. Keypad lockout and factory default overrides.

8. Adjustable slip compensation (+/- 5%).

J. The variable frequency drives shall be additionally equipped with a digital operator station mounted on the enclosure front door. Control operator devices and indication lights shall include:

1. Local digital speed control.

2. Hand-Off-Remote control selector switch.

3. LED status lights for each HOR position.

4. Momentary start/stop push buttons utilized with the HOR in “Hand”.

5. Local-Remote speed control selector switch.

6. LED status lights for each Local-Remote position.

7. LED status lights for run, fault, alarm, up-to-speed, power on, and drive ready status.

8. Additional controls as required by Division 11 and 13 and as shown on the Drawings. Pump Failure will require pump fail timer (as required). Provide for terminations of remote mounted operator control devices and field devices.

K. The variable frequency drives shall have the following system interfaces:

1. Inputs:

a. Two (2) isolated process control speed reference interfaces to receive and isolate 0-10 Vdc or 4-20 mAdc signals.

b. Dedicated terminal blocks for interface with remote operator and field devices.

c. 120 Vac control to allow variable frequency drives to interface with remote contacts and with two or three-wire control.

d. Additional inputs as required by Division 11 or 13 and as shown on the drawings.

2. Outputs:

a. Four (4) analog output signals 0-10 Vdc or 4-20 mAdc for external metering.

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b. Run relay with an isolated set of form C contacts.

c. Dry contact output (N.O.) to indicate protective function trip.

d. Dry contact output (N.O.) to indicate common alarm.

e. Additional outputs as required by Division 11 or 13 and as shown on the Drawings.

L. Monitoring and Displays:

1. The variable frequency drives shall have a 40-character vacuum fluorescent display indicating monitored functions as described in the following paragraph.

2. The following parameters shall be monitored:

a. Input current (3 phases)

b. Input voltage (3 phases)

c. Output current (3 phases)

d. Output voltage (3 phases)

e. Output frequency

f. Kilowatts

g. Drive temperature

h. Time

i. Date

j. Motor rpm

k. Ten (10) most recent trips/faults

M. Protection Functions:

1. The variable frequency drives shall have the following protective features (with indication for a. through i.):

a. Speed compensated electronic motor overload current.

b. Undervoltage.

c. Overfrequency.

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d. Overtemperature.

e. Ground Fault.

f. DC bus protection.

g. Inrush current limit (adjustable 50 to 150%).

h. Input and output phase loss.

i. Emergency stop pushbutton (Red mushroom head and maintained).

j. Current limiting fuses shall be provided on the input side of the VFDs to protect against fault currents up to 200,000 A sym.

k. The output side of the VFDs shall be equipped with a current limiting reactor to reduce the amount of fault current to the VFDs.

l. Phase insensitive to input power.

m. Surge protection from input AC line transients at line side of main circuit breaker.

n. Electrical isolation between the power, control and logic circuits.

o. Drive to be capable of withstanding output terminal line short or open circuits without component failure.

N. Additional Features shall be provided as follows:

1. The variable frequency drives shall be equipped with a flange mounted molded case input circuit breaker (65,000 AIC minimum). The breaker shall be interlocked with the enclosure doors to prevent access to the variable frequency drive unless the breaker is in the open position and to prevent moving the breaker to the ON position while the unit door is open. The circuit breaker shall have provisions for padlocking in the open position. Provide mechanical interlocks on doors of auxiliary sections of multi-bay or multi-cubical cabinets.

2. Fused space heaters with thermostat to minimize condensation potential upon drive shutdown.

3. The variable frequency drives shall be variable torque design. Provide constant torque design as required by Division 11.

4. Variable frequency drives shall be capable of unidirectional operation.

5. Variable frequency drives shall have 115 VAC control power for operator devices.

6. Control relays shall be machine tool type, heavy duty type, industrial grade, 600 volt, 10 amp rating, Square D, Class 8501, Type X or equal.

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7. All wiring shall be numbered at each end with permanent heat shrink markers. Wiring less than 6 inches may be numbered at only one end.

8. A copper ground bus.

9. Separate door-mounted output ammeter, ammeter switch, non-resettable elapsed time meter (0-99999.9 hour) and speed indicating meter in addition to those specified through the door display.

10. Power unit fan loss protection by automatically switching to a 100% spare cooling fan. Cooling fans shall be on when the variable frequency drive is operating and off when drive is off (fans shall run for a period of time after the variable frequency drive shuts down to dissipate heat and controlled by a thermal switch).

11. All bus and exposed copper shall be tin-plated.

12. All floor mounted enclosures shall have complete 18" (minimum) clear space in bottom of the cubical for line, motor and field cable terminations. All wall mounted enclosures shall have complete 12" (minimum) clear space in bottom of the enclosure for line, motor and field cable terminations.

13. Barriers and warning signs on terminals that are energized with the power disconnect OFF.

14. A 2-inch by 5-inch, nominal, engraved three-layer laminated plastic master nameplates on each VFD fastened with stainless steel screws or rivets. Nameplates shall be black letters with white background core, 3/8-inch high lettering and shall indicate equipment designation as shown on the Drawings.

15. Provide legend plates or 1-inch by 3-inch engraved nameplates with 1/4-inch lettering for identification of pilot devices and meters.

16. Provide permanent warning signs as follows:

    a. "DANGER - HIGH VOLTAGE - KEEP OUT" on all enclosure doors.

    b. "WARNING - HAZARD OF ELECTRIC SHOCK - DISCONNECT POWER BEFORE OPENING OR WORKING ON THIS UNIT".

17. A switchable fluorescent light within each floor mounted section of the enclosure.

O. The isolation/phase shift transformers shall be provided as follows:

1. Transformers shall be dry type, self ventilated, with insulation for 100 degrees C average temperature rise above 30 degrees C ambient at full continuous operation and shall be suitable for site ambient and altitude. Each shall be equipped with 120 volt single phase space heater(s) for moisture control.

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2. Transformer windings shall be copper and exposed copper and bussing shall be tin plated.

3. Impedance shall be selected by the drive system designer.

4. Transformer shall be designed for Inverter duty service with three phase, twelve-pulse or greater static power converter connected to the secondary windings. The increased eddy and stray losses due to harmonic currents shall be minimized and shall be included in the specified temperature rise.

5. A high temperature alarm and indication shall be provided.

6. Standards: The transformer shall meet the general requirements of ANSI C57.12.00 plus the applicable requirements of ANSI C57.18 (since it is for rectifier service). Tests shall be per ANSI C57.12.90. Additional dry type transformer construction requirements:

   a. Noise Level: The maximum sound level shall not be excessive and shall conform to NEMA Standard TR27-5.09.

   b. Nameplates: Nameplates, warnings, connection diagrams, etc., shall be in accordance with ANSI C57.12.00.

   c. Factory Tests: The routine tests listed in ANSI C57.12.00 shall be conducted on all transformers.

   d. Outline Drawings: To include weight, center of gravity, losses at rated load, DC resistance at 25 degrees C. and nameplate data.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Field wiring shall be in accordance with manufacturer's recommendations. Anchor bolts shall be set in accordance with the manufacturer's recommendations.

3.02 SHOP PAINTING

A. Prior to shop painting, all surfaces shall be thoroughly cleaned, dry, and free from all mill/scale, rust, grease, dirt, and other foreign matter.

B. Variable frequency drive enclosures shall be shop painted.

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3.03 INSPECTION, TESTING AND STORAGE

A. The Contractor shall notify the Engineer two weeks prior to all factory and field tests. The Engineer shall have the option to inspect all tests at the factory and in the field.

B. The manufacturer shall test the variable frequency drive with a motor load (full rated) prior to shipment for 4 hours. All printed circuit boards shall be tested at 50 degrees C for 40 hours. The variable frequency drive manufacturer shall provide the actual test data and certification that the tests have been completed prior to shipment to the Engineer for approval.

C. Field Tests:

1. Field tests of the drive shall be made by the manufacturer who will furnish all equipment and record all data. The Contractor shall be present during testing.

2. Field tests are the basis of demonstrating equipment proficiency and correct operation.

3. If the drive performance does not meet the Specifications, corrective measures shall be taken or the drive shall be removed and replaced with a drive which satisfies the conditions specified. A seven (7) day 24 hour (actual operation) operating period as specified herein of the drive will be required before acceptance. The Contractor shall provide for seven (7) day 24 hour (minimum) on-site supervision of the field acceptance tests. If a drive fails to perform and must be replaced, the rejected drive shall not be removed until the replacement drive has been delivered to the site. If corrective measures are to be taken, such measures shall be done on-site at such times as convenient to the Owner. The Owner shall be allowed to use any drive supplied immediately following installation and testing whether or not the equipment meets the conditions specified.

4. Factory representatives of the manufacturer who are competent and experienced and who have complete knowledge in the proper operation and maintenance of the equipment shall be provided to inspect and supervise the installation of the equipment and supervise the initial test run. The first visit will be for checking and inspecting the equipment during installation. The second visit will be to operate and supervise the initial field test. If problems are encountered in operation of the equipment additional service shall be provided at no additional cost to the Owner. These services are in addition to the services required for training.

5. Training will not be permitted until all equipment is fully operational. In the event that the equipment becomes inoperable under warranty provisions, additional training will be provided at no additional cost to the Owner as follows:

Inoperable Period	Additional Training
0-2 weeks	None
2-6 weeks	2 days
More than 6 weeks	5 days

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6. All training shall be coordinated and conducted concurrently with training to be supplied by the equipment and motor manufacturers.

7. Functional Test: Prior to plant start-up, all equipment described herein shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory performance by means of a functional test. Submit test procedure for review and approval by the Engineer.

8. Vibration Test: Vibration analyses shall be performed on the equipment when operating the variable frequency drive through its entire speed range. Where loads and drives are separated by intermediate flexible shafting, vibration shall be measured both at the top motor bearing and at two points on the equipment bearing, 90 degrees apart.

9. Performance Testing: Demonstrate system performance by operating the system for a seven (7) day continuous period while varying the application load, as the input conditions allow, to verify system performance. Record all data necessary to document the successful performance of the system. Provide all instruments, equipment, and labor required to accomplish this test. If a unit fails the performance test, the supplier will be allowed to readjust and retest the system. If the unit fails the second test, the unit will be rejected and the Contractor shall furnish a unit that will perform as specified.

10. Check each alarm and detection device for proper operation.

11. The drive manufacturer shall provide all necessary personnel and equipment necessary to properly start-up and pass all tests at no additional cost to Owner.

12. A copy of all tests and checks performed in the field complete with meter readings and recordings, where applicable, shall be submitted to the Engineer.

D. General:

1. All factory and field tests are typical for each variable frequency drive.

2. Electrical equipment shall at all times during manufacture, testing, delivery and construction be adequately protected against mechanical injury or damage by water. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry permanent shelters. Temporary connections shall be provided to operate space heaters and temporary lights required for heat shall be provided to control moisture. If any apparatus has been damaged prior to acceptance the Owner, such damage shall be repaired by the Contractor at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such special tests as directed by the Engineer, at the cost and expense of the Contractor, or shall be replaced by the Contractor at his own expense.

END OF SECTION

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SECTION 16500

LIGHTING SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete lighting systems including panelboards, transformers, lighting fixtures, receptacles, switches, contactors, and all necessary accessories and appurtenances required as hereinafter specified and shown on the Drawings.

1.02 STANDARDS

A. All lighting fixtures shall be in accordance with the National Electrical Code and shall be constructed in accordance with the latest edition of the Underwriters Laboratories "Standards for Safety, Electric Lighting Fixtures." All lighting fixtures shall be Underwriters Laboratories labeled.

PART 2 PRODUCTS

2.01 MATERIALS

A. Panelboards shall be as specified under Section 16470.

B. Transformers shall be as specified under Section 16191.

C. Conduit shall be as specified under Section 16110.

D. Wire shall be as specified under Section 16120.

E. Switches

1. Wall switches shall be of the indicating, toggle action, flush mounting quiet type. All switches shall conform to Federal Specification WS896-E.

2. Wall switches shall be of the following types and manufacturer or equal.

a. Single pole - Arrow-Hart, Catalog Number 1991, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

b. Double pole - Arrow-Hart, Catalog Number 1992, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

c. Three way - Arrow-Hart, Catalog Number 1993, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

d. Four way - Arrow-Hart, Catalog Number 1994, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

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e. Single pole, key operated - Arrow-Hart Catalog Number 1991-L, or equal.

f. Single pole, pilot indicating - Bryant Catalog Number 4901-PLR120, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

g. Weatherproof cover for standard toggle switches - Crouse-Hinds Catalog Number DS181, or equal by Appleton Electric Co., L.E. Mason Co., or equal.

F. Receptacles

1. Receptacles shall be of the following types and manufacturer or equal. Receptacles shall conform to Federal Specification WC596-F.

a. Duplex, 20A, 125V, 2P, 3W; Arrow-Hart, Catalog Number 5362, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

b. Weatherproof or corrosion resistant single, 20A, 125V, 2P, 3W, Harvey Hubbell, Inc., Pass & Seymour, Inc., with Taymac Corp., 303106 cover, or equal.

c. Weatherproof or corrosion resistant duplex, 20A, 125V, 2P, 3W Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.; with Taymac Corp., 103106

d. Ground fault interrupter, duplex, 20A, 125V, 2P, 3W; Arrow-Hart Catalog Number GF 5342, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

e. Duplex, 20A, 125V, 2P, 3W with transient voltage surge suppressor and indicator light; Pass & Seymour Catalog 6362-GRY-5P, equal by Harvey Hubbell Inc., Bryant Electric Co., or equal.

f. Stainless steel indoor mounting plate for G.F.I. receptacle; Arrow-Hart Catalog Number 97061, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc. or equal.

g. Weatherproof covers for G.F.I. receptacles shall be Taymac Corp., Catalog Number 203106, or equal.

h. Explosion-proof, 20A, 125V, 2P, 3W; Appleton Electric Co. Catalog Number EFS175-2023 or EFSC175-2023 or equal by Crouse-Hinds Co., Killark Electric Manufacturing Co., or equal. Furnish one Appleton Electric Co. Catalog Number ECP-1523 cap or equal by Crouse-Hinds Co., Killark Electric Manufacturing Co., or equal for every two receptacles (minimum of one).

i. Single, 20A, 250V, 2P, 3W; Arrow-Hart Catalog Number 5861, or equal by Harvey Hubbell, Inc., Pass & Seymour, Inc., or equal.

j. Single, 30A, 125V, 2P, 3W; Arrow-Hart Catalog Number 5716; cap: Arrow-Hart Catalog Number 5717.

k. Single, 30A, 250V, (3 phase) 3P, 4W; Arrow Hart Catalog Number 8430N; Cap: Arrow-Hart Catalog Number 8432AN.

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2. Multi-Outlet Assembly

   a. Assembly enclosures shall consist of two piece, all steel or anodized aluminum raceways which shall allow for field installation of wiring and standard receptacles as shown on the Drawings.

   b. Multi outlet assemblies shall be UL Listed as a Multi-outlet assembly.

   c. Raceways bases and removable covers shall be .040-in steel, minimum of 2-1/8-in high by 1-5/8-in. deep. Entrance fittings shall be sized for 3/4-inch conduit.

   d. Raceways shall include all fittings, couplings, etc. for complete installation of a finished system.

   e. Device covers shall be the G-4000 and G-6000 Series by Wiremold; Isoduct or equal by Walker or equal.

   f. The multi-outlet assemblies shall be the G-4000 and G-6000 Series (as shown) by Wiremold or equal by Isoduct; Walker or equal.

G. Device Plates

1. Plates for flush mounted devices shall be of the required number of gangs for the application involved and shall be 302 (18-8) high nickel stainless steel of the same manufacturer as the device.

2. Plates for surface mounted device boxes shall be of the same material as the box.

H. Lighting Fixtures

1. Lighting fixture types shall be as shown on the "Lighting Fixture Schedule" on the Drawings. The catalog numbers listed are given as a guide to the design and quality of fixture desired. Equivalent designs and equal quality fixtures of other manufacturers will be acceptable.

I. Lamps

1. Fluorescent lamps shall be medium bi-pin and recessed double contact, rapid start, standard cool white and biaxial types all as shown on the "Fixture Schedule."

2. Fluorescent ballasts shall be energy saving, Class P, rapid start, high power factor, CBM certified by E.T.L. and listed by Underwriters Laboratories, Inc., for operation on 120 volts or as shown on the "Lighting Fixture Schedule." Ballasts shall have ballast efficiency factors (BEF) of: 1.805 for 1-F40T12 lamp and 1.060 for 2-F40T12 lamps.

3. High pressure sodium lamps shall be clear and of the size and type as shown on the "Lighting Fixture Schedule."

4. High pressure sodium ballasts shall be of the constant wattage type of the correct size and voltage for the fixture it is to serve as shown on the "Lighting Fixture Schedule." All

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ballasts shall be as manufactured by Advance Transformer Co., Holophane Lighting, MagneTek Universal Manufacturing, or equal.

5. Metal halide lamps shall be clear and of the size and type as shown on the "Lighting Fixture Schedule."

6. Metal halide ballast shall be of the constant voltage auto-transformer type of the correct size and voltage for the fixture it is to serve as shown on the "Lighting Fixture Schedule." All ballasts shall be as manufactured by Holophane Lighting, MagneTek Universal Manufacturing, Advance Transformer Co., or equal.

7. Incandescent lamps shall be inside frosted, extended service, 2500 hour life with medium base.

8. All lamps shall be of one manufacturer and shall be as manufactured by Sylvania Electric Products, Inc., General Electric Co., North American Philips Lighting Corp., or equal.

J. Flexible Fixture Hangers

1. Flexible fixture hangers used in non-hazardous areas shall be type ARB and flexible fixture supports used in hazardous areas shall be type ECHF as manufactured by the Crouse - Hinds Co., Appleton Electric Co., Killark Electrical Manufacturing Co., or equal.

K. Lighting Contactor

1. Lighting contactors shall be of the electrically operated, type in NEMA 1 enclosures of the number of poles as called for on the Drawings.

2. Contactors shall be rated for 30A-600 volt A.C. contacts and be similar and equal to Automatic Switch Co. bulletin 917 RC, Square D Co., Westinghouse Electric Corp., or equal.

L. Photo Electric Controls

1. Photo electric control with time delay for outdoor lighting shall be completely self-contained and not affected by moisture, vibration or temperature changes.

2. ON/OFF adjustments are to be made by movement of a light level selector without the use of tools in a range from 2 to 50 foot candles.

3. Photo electric control device shall be SPST, and have 2000 watt tungsten capacity and be Tork Catalog Number 2101 (120V); 2104 (208-277V) or equal by Intermatic Inc., Carlon, or equal.

4. Photo electric control for use in conjunction with electrically operated, mechanically held lighting contactors shall have a turn-lock photo control device. The complete assembly shall be NEMA 3 rainproof construction with a SPDT, 1000 watt capacity relay and be Tork Catalog Number 5420 with a Model TMC-1 adapter for momentary contact operation or equal by Intermatic Inc., Carlon, or equal.

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M. Emergency Lighting Battery Units

1. Emergency lighting units shall be fully automatic with (12-volt) lead acid batteries. Units shall be designed for (120) volt, 60 Hertz input and have a sealed mercury relay, solid state charger, ready/off switch, press-to-test switch, amber "ready" light, volt meter and required number of supervisory relays.

2. Emergency lighting units shall be Emergency Lighting and Systems Inc. series, Chloride, Inc., Dual-Lite, or equal of capacities as indicated on the Drawings and be complete with all necessary mounting hardware.

3. Emergency lighting units shall each be equipped with a time delay relay to maintain emergency lighting in H.I.D. source lighted areas for 5 minutes after return of normal power.

4. Remote adjustable, wall mounting lighting heads shall each have 12 watt halogen lamps and be Emergency Lighting and Systems Inc. model RDQ or equal by Chloride, Inc., Dual-Lite, or equal.

5. Remote flush ceiling mounted lighting heads shall each have a 28 watt, 32 C.P. lamp and be Emergency Lighting and Systems Inc. model RNF or equal by Chloride, Inc., Dual-Lite, or equal.

6. Remote adjustable, wall mounting lighting heads for Class 1, Division 1, Group D hazardous areas shall each have a 25 watt sealed beam lamp and be Emergency Lighting and Systems Inc. model RXPS or equal by Chloride, Inc., Dual-Lite, or equal.

7. Remote adjustable, wall mounting, vaportight lighting heads each with 25 watt sealed beam lamps and be Emergency Lighting and Systems Inc. model RVT or equal by Chloride, Inc., Dual-Lite, or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Each fixture shall be a completely finished unit with all components, mounting and/or hanging devices necessary, for the proper installation of the particular fixture in its designated location and shall be completely wired ready for connection to the branch circuit wires at the outlet.

B. When fixtures are noted to be installed flush, they shall be complete with the proper accessories for installing in the particular ceiling involved. All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceilings for their support.

C. Flexible fixture hangers shall be used for all pendant mounted fixtures.

D. Conduit run in areas with hung ceilings shall be installed in the space above the hung ceiling as close to the structure as possible. Conduits shall be supported from the structure.

E. Switch and receptacle outlets shall be installed flush with the finished floor or wall when raceways are shown as "concealed" on the Drawings.

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F. Receptacles in process areas and shops shall be mounted 36" above the floor unless otherwise noted on the Drawings.

G. Receptacles in office and other like areas shall be mounted 18 inches above the floor unless otherwise noted on the Drawings.

3.02 REPLACEMENT

A. Lamps (except for H.I.D.) used during the building construction, prior to two weeks from completion of the work, shall be removed and replaced with new lamps.

3.03 CLEANING UP

A. Plastic dust cover bags to be provided with new parabolic reflector lighting fixtures shall be removed after all construction activity that may cause dust formation on reflector surfaces has been completed.

B. All fixtures shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

END OF SECTION

Memorandum

To: *Recipients of Request for Proposal*

From: *Carrie Carden, CDM Smith*

Date: *September 24, 2014*

Subject: *City of Franklin, Tennessee*
Franklin WRF Modifications & Expansion Project
Thermal Hydrolysis System RFP – Addendum No. 1

The deadline to submit proposals is hereby changed to **5 p.m. Eastern Time on Friday, October 24, 2014.** Questions concerning this RFP must be received no later than noon Eastern Time on Tuesday, October 21.

Please do not hesitate to contact us if you have any questions or concerns.

cc: David Parker, P.E., City of Franklin
Mark Hilty, P.E., City of Franklin
Bob Huguenard, P.E., BCEE, CDM Smith
Richard Tsang, Ph.D., P.E., BCEE, CDM Smith
Tom Nangle, CDM Smith

Memorandum

To: *Recipients of Request for Proposal*

From: *Carrie Carden, CDM Smith*

Date: *October 20, 2014*

Subject: *City of Franklin, Tennessee*
Franklin WRF Modifications & Expansion Project
THP System RFP – Addendum No. 2

This Addendum to the Request for Proposals (RFP) dated October 20, 2014, consists of the following items:

- Extension of the deadline to submit proposals as listed below.
- Modifications to:
  - The Cover Letter
  - Specification Sections 01025A, 11243 and 11351.
  - Attachments C, D and F.
- Addition of Specification Section 13306.
- Responses to questions and comments received as of close of business on Wednesday, October 15.

Only the Addition of Specification 13306 and Modifications to the Cover Letter, Specification Sections 01025A, 11243, 11351 and Attachment C, D and F will become a part of the Contract Documents. Questions, comments and responses included in this Addendum will not become a part of the Contract Documents.

The deadline to submit proposals is **5 p.m. Eastern Time on Friday, October 31, 2014**. Questions concerning this RFP must be received no later than noon Eastern Time on Tuesday, October 28.

Please do not hesitate to contact us if you have any questions or concerns.

Modifications to the Cover Letter

1. Page 3, 1st Paragraph that starts with "Section 10": Add the following sentence to the end of this bullet:

   "If certification as an equivalent Class A technology requires an extensive testing period, include a plan for handling and disposing of non-class A sludge produced during the testing period."

Modifications to Specification Section 01025A

1. Page 01025A-7, Paragraph 2.05A: Add the following subparagraph:

   "2. If certification as an equivalent Class A technology requires an extensive testing period, the THP System Supplier shall also include the cost of the alternative approach of testing the sludge discharge for enteric viruses and helminth ova to achieve Class A during this testing period."

Modifications to Specification Section 11243

1. Page 11243-3, Paragraph 1.03B: Delete the second sentence in its entirety, and insert the following sentence in its place:

   "The storage capacity of each bin shall be 60 cubic yards to maintain operation of the THP process for a minimum of 6 hours at ultimate (phase 2, year 2040) maximum month flow rates; this equates to a minimum of 12 hours of combined storage at ultimate maximum month flow rates."

2. Page 11243-4, Paragraph 1.04D: Replace Paragraph 1.04D.7 with the below paragraph.

   "Evidence of ISO 9001:2008 certification. If certification cannot be provided, a written quality assurance, quality control plan shall be submitted."

3. Page 11243-7, Paragraph 2.01A.4: Delete the first instance of the word "(minimum)".

Modifications to Specification Section 11351

1. Page 11351-8, Paragraph 1.06.D.3: Replace the pre-dewatered WAS projected flow rates and characteristics table with the below table.

TABLE 1: Pre-Dewatered WAS Characteristics

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	20,173	26,225	26,897	34,966	43,035	55,946
TS (%)[1]	18%	18%	18%	18%	18%	18%
Flow Rate (gal/day)	13,438	17,469	17,917	23,292	28,667	37,268
VS as % of TS (%)[2]	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%
VS (lb/day)	13,112	17,046	17,483	22,728	27,973	36,365

[1] The % dry solids cake delivered will range between 16%-20%.
[2] The expected volatile solids (VS) average is 65% of the total solids; however the Supplier should expect to see a range between 60-70% VS.

2. Page 11351-9, Paragraph 1.06.E.3: Replace the FOG projected flow rates and characteristics table with the below table.

TABLE 2: FOG Characteristics

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	667	1,001	801	1,201	1,168	1,768
TS (%)[1]	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
Flow Rate (gal/day)	2,000	3,000	2,400	3,600	3,500	5,300
VS as % of TS (%)[2]	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
VS (lb/day)	567	851	681	1,021	993	1,503

[1] The expected total solids (TS) average is 4%; however the Supplier should expect to see a range between 4-10% TS.
[2] The expected volatile solids (VS) average is 85% of the total solids; however the Supplier should expect to see a range between 80-90% VS.

3. Page 11351-11, Paragraph 1.06.I.2: Insert the following subparagraph in between "*Coordinating with the appropriate EPA and TDEC officials*…" and "*Hiring an approved laboratory to complete tests*…":

"2. Coordinating and covering the costs for intermittent discharge testing for enteric viruses and helminth ova to achieve Class A sludge during the Class A equivalency testing period."

4. Page 11351-18, Paragraph 2.10: Delete subparagraph A and replace it with the following subparagraph:

   "One sludge/water heat exchanger shall be provided by the THP System Supplier in phase 1. This heat exchanger will be sized to cool the incoming mixture of hydrolyzed and digester recirculated sludge to 100 degrees Fahrenheit under phase 1 maximum month loads per the THP System Supplier's mass flow diagrams. An identical heat exchanger shall be provided in phase 2 by the THP System Supplier."

Modifications to Attachment C

1. Page 1, First Paragraph under the "*Pre-Dewatered WAS Characteristics for Each Loading Scenario*" Section: Delete line 3 from the paragraph and replace it with:

   "…to between 16% and 20% dry solids…"

2. Page 1, Second Paragraph under the "*Pre-Dewatered WAS Characteristics for Each Loading Scenario*" Section: Delete the second sentence in the paragraph

3. Page 1: Replace Table 1 with the following Table:

TABLE 1: Pre-Dewatered WAS Characteristics

	Initial Startup Loads, Year 2018		Phase 1 Design Loads, Year 2025		Phase 2 Design Loads, Year 2040	
	Avg. Day	Max Month	Avg. Day	Max Month	Avg. Day	Max Month
TS (dry lb/day)	20,173	26,225	26,897	34,966	43,035	55,946
TS (%)[1]	18%	18%	18%	18%	18%	18%
Flow Rate (gal/day)	13,438	17,469	17,917	23,292	28,667	37,268
VS as % of TS (%)[2]	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%
VS (lb/day)	13,112	17,046	17,483	22,728	27,973	36,365

[1] The % dry solids cake delivered will range between 16%-20%.
[2] The expected volatile solids (VS) average is 65% of the total solids; however the Supplier should expect to see a range between 60-70% VS.

Modifications to Attachment D

1. Page 2, Paragraph 2 under Operational Items: Delete Paragraph 2 in its entirety.

2. Page 3, Paragraph 3.b under Operational Items: Delete the phrase "…and contaminant concentrations…" from the paragraph.

3. Table 3: Operational Bid Items: Delete the "Operational Item 2" row in its entirety.

Modifications to Attachment F

1. Page 3, Class A Biosolids Section: Insert the following bullet in between the "*Coordinating with the appropriate EPA and TDEC officials*…" and "*Hiring an approved laboratory to complete tests*…" bullets:

   "2. Coordinating and covering the costs for intermittent discharge testing for enteric viruses and helminth ova to achieve Class A sludge during the Class A equivalency testing period."

Addition of Specification 13306

1. Specification Section 13306 "Applications Engineering Services" is added to clarify the requirements for the THP System PLC and its associated equipment.

Questions & Comments Received as of October 6, 2014

Item	Paragraph	Question/Comment	Response
1	11243-3: 1.03.A	2040 Max flows stated in Attachment C Table 1 indicate 55,946 dry lb/day or 2,331 dry lb/hr. The statement in the bin section conflicts with this number. Please clarify what throughput the bin sizing should be based on.	Specification 11243 has been modified to require a 60 cubic yard storage capacity for each bin.
2	01025A-6: 2.03.B	Note item B states "payment of fourth five (50) percent…"; Please confirm the correct percentage.	The correct percentage is fifty (50) percent.
3	11243-4: 1.04.D.7	Please confirm if this applies to all THP supplied equipment. All components supplied by us are not necessarily sourced from ISO certified shops. Please confirm if a quality assurance program in lieu of ISO 9000 certification is acceptable.	No, the ISO certification does not apply to all equipment. Yes a written quality assurance, quality control plan may be submitted in lieu of ISO certification per paragraph 1.04.D.7. Paragraph 1.04.D.7 has been modified in this addendum to make the requirements more clear.
4	11243-1: 1.01.A.7	What is the purpose of this air inlet for the sludge storage bins? Please confirm this is necessary.	Confirmed; the air inlet is necessary and serves to provide fresh make up air for odor control.
5	11243-8: 2.02	Based upon our experience, we believe painted carbon steel is adequate for the sludge storage bins. Please confirm painted carbon steel is an acceptable alternative to 316/316L. In addition, we believe 304/304L SS is adequate for the cake piping. Please confirm 304/304L is an acceptable alternative to 316/316L.	The sludge storage bins shall be 316/316L to extend the life and limit system downtime. For the cake piping, please bid on 316/316L, but provide a separate deduct for switching from 316/316L to 304/304L.
6	11351 General	Will the Solids Handling Building or areas in the Solids Handling Building be Classified and, if so, what is this Classification?	The sludge storage bin area in the Solids Handling Building will be unclassified. Please see 11351-14; 2.02.A.
7	11351 General	Will the area where the THP Pad is located be Classified?	The THP pad will only contain equipment supplied by the THP System Supplier. It is the responsibility of the THP System Supplier to identify classified areas on the THP pad due to equipment in their scope. Adjacent structures are not anticipated to affect the classification of the THP pad.
8	11351-9: 1.06.E.1	Please clarify if THP supplier shall supply the pump to convey flow from the heated tanks to the pasteurization system.	No, the FOG feed pumps and piping to the THP pad will be supplied by others. The THP System Supplier shall be responsible for all FOG piping on the THP pad.

Item	Paragraph	Question/Comment	Response
9	11351-10: 1.06.F.1	Please confirm that the reuse water is pathogen free. If it is not pathogen free, it can effect whether or not the final end product meets Class A standards. We will not be able to guarantee Class A if this is not the case.	The plant reuse water is pulled from the plant effluent downstream of the UV disinfection system. The water is then chlorinated to maintain chlorine residual throughout the reuse conveyance piping in order to prevent pathogen growth in the piping.
10	11351-10: 1.06.H	Please clarify what is required as part of the Local Control Panel (Disconnect Mechanism, Hand Off Auto, etc).	Please refer to paragraph 2.02 in Specification 16191A for requirements of equipment control panels.
11	11351-11: 1.07.B	Is a spare PLC Processor required?	No.
12	11351-18: 2.12	For motors associated with the THP that require FVNR Motor Starter's, who is responsible for supplying these?	The THP system supplier is responsible for supplying all motors and starters for equipment provided by the THP system supplier.
13	11351-18: 2.13	Is there sufficient space available in the Solids Handling Building Electrical Room to locate the VFD's associated with the THP? Should VFD's be supplied in an individual Wall Mount enclosure or a MCC style layout?	VFDs shall be located in the Local Control Panels for each piece of equipment. See paragraph 2.02 in Specification 16191A for requirements. Also see Specification 16370 for additional requirements.
14	11351-3: 1.03.A.14	Will the THP Supplier be required to provide Graphic Screens that would be used for the Plant SCADA System? Is the THP Supplier required to provide an Operator Interface and, if so, what type, model etc?	The THP supplier shall not provide graphic screens to be used for the Plant SCADA System. The THP supplier shall provide an Operator Interface with graphic screens for the THP system. The Operator Interface shall be Allen-Bradley Panel View Plus - touchscreen of 10 inch nominal size or greater.
15	11351-4: 1.03.C	Does the Harmonics Testing have to be performed onsite or can Harmonics Software evaluation be performed?	Harmonics testing shall meet the requirements set forth in paragraph 1.09 in specification 16370.
16	11351-9: 1.06.E	This table does not match the loading detailed in the FOG table in Appendix C. Please confirm the loading criteria to which the designs must satisfy.	The correct FOG loading is detailed in Attachment C. The table in Specification 11351 is being replaced to match Attachment C in this addendum.

Item	Paragraph	Question/Comment	Response
17	13300-13: 1.11	There were no drawings available at the time of this review. Please provide these drawings for review.	Electrical drawings will not be available until after the THP Pre-Selection. Part 2 of specification 11351 provides information on hazardous area classifications for THP equipment located in the Solids Handling Building and the Digester Building. The THP System Supplier is to determine the area classifications on the THP equipment pad based on the equipment they are providing (see response to question 7 above).
18	13311-12: 2.09	Is the THP Supplier required to supply PLC and HMI Programming Software or is this the responsibility of the Systems Integrator?	The THP Supplier is not required to supply copies or licenses of PLC and HMI programming software to the Owner. However, the THP Supplier is responsible for obtaining any tools, including software, required to furnish the THP system.
19	13311-13: 2.10	Please confirm that the reprogramming of the referenced Maple Systems OIT is the responsibility of others and not the THP Supplier.	Reprogramming of the Maple System OIT is the responsibility of others.
20	13320-3: 2.02	Is a Managed Ethernet Switch required in the THP Central Control Panel?	The Managed Ethernet Switch is required in the THP Central Control Panel in order to connect to the PLC, OIT, and the broader SCADA system. The switch will also have fiber ports to receive data from the RIOPs as well.
21	13320-4: 2.05	Is the THP Supplier required to supply a Spare Ethernet Switch?	No.
22	13330-11: 2.09.C	Is the specified color convention applicable to the SCADA and HMI Screens?	No, the color convention for SCADA and HMI screens shall be as shown in the approved preliminary graphic screen submittal as listed in Specification 13306 – Applications Engineering Services. The THP supplier will need to coordinate with the PCSS to obtain this information. Specification 13306 has been added to the Contract Documents as part of this Addendum.
23	16370-1: 1.01.A	Please confirm that VFD's for the THP are to be supplied by the THP Supplier and installed and field wired by others.	The control panels and VFDs will be provided by the THP Supplier. The VFDs will be provided in the control panels, and should therefore be pre-wired. Conduit and wiring from the control panels to the equipment shall be provided by the THP Supplier and field wired by others.

Item	Paragraph	Question/Comment	Response
24	16370-2: 1.03.G	Is there a particular Model of Allen Bradley VFD that is required?	No, the model for a given application would have to meet the requirements set forth in specification 16370 and in Paragraph 2.02C in specification 16191A.
25	Appendix D, Operational Items	Only temperature information is given in 1.06.F.2, but no contaminant information has been provided. Please confirm this contaminant information.	Attachment D has been modified to remove the reference to contaminant information as part of this addendum. Please see response to question 9 for concerns on plant reuse water contamination.
26	Cover Letter Page 1 Paragraph 3	The cover letter states the following. "*For the purposes of our economic analysis, we would like to receive two proposals, one for each of the above listed phases. If additional equipment is not necessary to bring the THP system from Phase 1 to Phase 2, please state so in your response to this RFP.*" Could you please provide direction on what specific sections (i.e. Section 1: Bid Form) defined within the cover letter should be included for the Phase 2 proposal. I assume that you are not interested in us repeating sections (such as the Bid Form) in both the Phase 1 and 2 proposals.	The overall biosolids upgrades are being conducted in two phases; phase 1 is installing all equipment and processes for phase 1 design loads, phase 2 is the installation of additional process units to handle phase 2 loads (e.g. two digesters are being installed in phase 1, with a third being installed in phase 2). If the THP system that is being proposed can handle phase 2 loadings without expansion, please state so in your proposal and put $0 values in the "Phase 2 Budget Cost" column on Table 1 of the bid forms. If the THP system that is being proposed requires additional equipment (e.g. reactor volume) to handle phase 2 loadings, than the cost of that additional equipment shall be entered in the "Phase 2 Budget Cost" column on Table 1 of the bid forms. Also, additional information should be provided to the proposal sections to provide adequate information on the equipment being added under phase 2; the exceptions to this being Sections 8, 9, 11 & 12.
27	General Question	What is the local electrical rate (now and anticipated)?	$0.095/kWh, assume 3% annual escalation
28	General Question	What is the electrical demand of the entire plant (now and anticipated)?	The plant demand will always exceed the potential energy production of the CHP system.
29	General Question	What is the local natural gas rate (now and anticipated)?	$7.83/MMBTU, assume 3% annual escalation
30	General Question	What is the anticipated size of the cogeneration engine?	This will depend on the THP supplier selected, as different steam loads are required for each. A 630 kW engine is being used as a placeholder based on estimated steam load requirements for both suppliers.

Item	Paragraph	Question/Comment	Response
31	General Question	Is a 2nd engine planned as the plant grows?	Yes, the year it will be required depends on the ultimate size of the engine selected and the selected THP System's required steam loads.
32	General Question	How is steam produced when the cogeneration engine is down?	Dedicated backup boilers in the digester building.
33	General Question	With diurnal flows and fluctuations in gas production, what is the plan for producing enough steam during slow periods?	Natural gas will augment the biogas from the digesters to produce the required steam. Additionally, excess biogas will be stored in a gas storage membrane (provided by others).
34	General Question	Please confirm there is no opportunity to sell the power if more power is produced than consumed.	Confirmed, the CHP system will not produce more power than the plant can consume.
35	General Question	It is my understanding that the FOG will be transferred from the FOG unloading station to a number of FOG storage tanks where they will be kept heated using hot water from the CHP. What temperature will the FOG be held at in these tanks before we take it into our FOG pasteurization tank and further heat it to achieve Class A?	Your understanding is correct. The plan is to heat the FOG in the tank to 110 degrees F. However, the THP suppliers shall assume that the FOG and pre-dewatered WAS delivered into the THP scope is not heated; assume a range of 50-60 degrees F when designing your systems.
36	Attachment C – Page 1	While it may be possible to get 22% dry solids as a maximum, it will be unlikely that the plant will operate at the maximum achievable % solids. For bid purposes we suggest that the bids be required to be based on 18% dry solids feed. Otherwise, as written, bids can be based on 22% solids. This will understate the volumetric flow and could lead to undersized process equipment. For mass & energy balances, 22% solids will understate the energy. Again 18% should be the value used for all equipment sizing providing a range of 15-21% as a more realistic solids content.	After further consideration of pilot dewatering testing results, the presence of upstream sludge screening, and the unknown dewaterability of sludge produced by the new secondary treatment process, we believe that the percent cake solids delivered to the sludge storage bins will be 18% - plus or minus 2%. The THP System Supplier shall design around the expectation of 18% solids being delivered, but have the ability to handle solids between 16-20%. Attachment C, Attachment D, and Specification 11351 have been modified to reflect these changes.

Item	Paragraph	Question/Comment	Response
37	General Comment	We suggest the bid documents require the vendor to include a stand-alone boiler with their scope and price. While we recognize there will likely be a heat recovery steam generator(s) on the final design, a fully redundant boiler will be needed to produce steam in the event that the CHP engines are not running and as a standby in case the heat recovery system is not operational.	Two dedicated boilers are being provided under this project by others. The sole function of the boilers is to produce steam for the THP system when the CHP system is down. The combined boiler capacity will be designed to provide the necessary steam for the THP system under year 2040 maximum month loads. The boilers are not in the THP Suppliers scope.
38	General Comment	We understand that there will be two digesters at Phase 1. The digesters will be sized such that, one digester may be out of service. Therefore, the specification should require that there shall be two cooling systems (one per digester) for Phase 1 and that each cooling system shall be sized to cool the max month rate to a single digester. Phase 2 pricing would then require a third cooling system of equal size (for the third digester).	The digesters are not sized to be 100% duty/standby. Due to the low hydrolyzed sludge flows, the hydrolyzed sludge – mixed with recirculated digester sludge – will be cooled through a single cooling heat exchanger, and then will be routed to a dedicated digester; only one digester will be fed at a time in phase 1. The THP Suppliers shall provide one cooling heat exchanger to handle phase 1 maximum month cooling loads. An identical cooling heat exchanger would be provided in phase 2. The second heat exchanger will provide the necessary additional cooling capacity required for phase 2 heat loads. Specification 11351 has been modified to reflect these changes.
39	Section 11243- ; 1.03	Part 1.03 could be interpreted that one bin could furnished as Phase 1 Bid and a second hopper for Phase 2 Bid. Suggest the spec clearly indicates two bins are required for phase 1.	Two live storage bins shall be provided in phase 1 per Paragraph 1.03.A.
40	Section 11243; 1.03	Part 1.03 specifies a range of feed solids. This can leave the storage volume open to debate. Suggest you specify that required capacity for each bin, which should be 1,400 ft^3 or 40 m^3.	Specification 11243 has been modified to require a 60 cubic yard storage capacity for each bin.

Item	Paragraph	Question/Comment	Response
41		There are two major reasons for placing a Thermal Hydrolysis (THP) system at the Franklin WWTP. The first is to produce a Class A product, while the second is reduce the total volume of the digesters, which directly reduces the cost of the digesters. We suggest the RFP should have some protection for the City, in case either of the two benefits they expect is not achieved. a. Attach F page 3: Vendor has 2 years after commissioning to obtain Class A approval? Who pays the additional disposal cost for 2 years? The sludge will have to go to a landfill until approval is obtained. The City will be exactly where they are today with their sludge. b. There is nothing in the RFP that indicates the size of the digesters planned for the plant. There is no requirement for proposers to provide in Section 9 of the Proposals, the size of the digesters at the reference installations and also the digester loading rate. What is the sense of installing THP if there is no savings in digester size?	The City is protected by the Performance Guarantees and Liquidated Damages listed in Specification 11351 and Attachment F. a. Per conversations with EPA and TDEC officials, approximately 2 years of extensive testing is what will be required for a continuous flow reactor to achieve certification as a Class A Equivalent Technology. The THP supplier shall be responsible for all costs associated with this testing per Specifications 01025A and 11351. Additionally, specifications 01025A and 11351 will be modified to require the THP System Supplier to pay for the cost of additional monthly sludge testing needed to achieve Class A status during the Class A Equivalency Testing Period. The THP Suppliers shall also submit a description of how they will achieve certification as an equivalent Class A technology per Section 10 of the cover letter. Section 10 of the Cover Letter and Attachment F will be modified as part of this addendum to require the proposal to include a plan of how to handle non Class A sludge produced during the testing period. b. The digesters shall be sized for 12 days Solids Retention Time (SRT) based on annual average day solids loading OR 15 days SRT for average day maximum month solids loading, whichever is largest. This reduced SRT provides the savings on the digester sizing.
42	Cover Letter Section 9	We suggest the requirements of Section 9 include, in addition to what is specified, requirements to provide the size of the digesters at each reference and the solids loading rate (lbs VS/1,000 cu.ft/day).	The size of the digesters is designed by others and has been provided for the bidders reference on page 4 in Attachment F.

Item	Paragraph	Question/Comment	Response
43	General Question	Do you have any information on the hot water coming from the CHP? Flow rate, temp, pressure?	There will be no hot water provided from the CHP system to the THP system. The CHP system is only providing saturated steam at the loading rate required by the winning THP System Supplier. All other thermal loads created from the CHP system will be used for other process and building needs by others.

cc: David Parker, P.E., City of Franklin
Mark Hilty, P.E., City of Franklin
Bob Huguenard, P.E., BCEE, CDM Smith
Richard Tsang, Ph.D., P.E., BCEE, CDM Smith
Tom Nangle, CDM Smith

Memorandum

To: *Recipients of Request for Proposal*

From: *Carrie Carden, CDM Smith*

Date: *October 28, 2014*

Subject: *City of Franklin, Tennessee*
Franklin WRF Modifications & Expansion Project
Thermal Hydrolysis System RFP – Addendum No. 3

This Addendum to the Request for Proposals (RFP) dated October 28, 2014, provides confirmations to questions received as of noon on Tuesday October 28, 2014. Questions, comments and responses included in this Addendum will not become a part of the Contract Documents.

The deadline to submit proposals is **5 p.m. Eastern Time on Friday, October 31, 2014.** No further questions will be received as the deadline for receiving questions has passed.

Please do not hesitate to contact us if you have any questions or concerns.

Questions & Comments Received as of October 28, 2014

Item	Paragraph	Question/Comment	Response
1	11243-3: 1.01.A.8	Please confirm that four rectangular sludge discharge connections are required on the top of each dewatered sludge storage bin.	Confirmed; four rectangular sludge discharge connections are required on the top of each dewatered sludge storage bin.
2	General Question	Please confirm the number of digesters being constructed in phase 1 and phase 2, respectively.	There will be two digesters installed in phase 1, with an additional digester installed during phase 2. The phase 1 digesters will be 40 foot diameter with a 40 foot side water height.
3	General Question	Are we to assume two digesters for the initial installation for phase 1 (2025) and the addition of a third identical digester in phase 2 (2040)?	See answer to Question 2 above. It is anticipated the 3rd additional digester in phase 2 will be sized similarly to the phase 1 digesters, but the sizing will be determined during phase 2 design based on historical plant data. Phase 1 includes equipment and processes required to process year 2018 to year 2025 projected biosolids loading. Phase 2 includes additional equipment required to process year 2026 to year 2040 projected biosolids loading.

Item	Paragraph	Question/Comment	Response
4	General Question	Is the third digester built in year 2026 or year 2040?	It is anticipated that the third digester will be operational in year 2026.

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Richard Tsang, Ph.D., P.E., BCEE, CDM Smith
Tom Nangle, CDM Smith

Memorandum

To: *Recipients of Request for Proposal*

From: *Carrie Carden, CDM Smith*

Date: *October 30, 2014*

Subject: *City of Franklin, Tennessee*
Franklin WRF Modifications & Expansion Project
THP System RFP – Addendum No. 4

This Addendum to the Request for Proposals (RFP) dated October 30, 2014, responds to questions received after the noon deadline on Tuesday October 28, 2014. Questions, comments and responses included in this Addendum will not become a part of the Contract Documents.

The deadline to submit proposals is **5 p.m. Eastern Time on Friday, October 31, 2014**. Please note our response to Question 12 regarding electronic and hard copy delivery of proposals. No further questions will be answered as the deadline for receiving questions has passed.

Please do not hesitate to contact us if you have any questions or concerns.

Questions & Comments Received as of 12 p.m. ET October 29, 2014

Item	Paragraph	Question/Comment	Response
1	Addendum 2, Modifications to Cover Letter	As stated, "If certification as an equivalent Class A technology requires an extensive testing period, include a plan for handling and disposing of non-class A sludge produced during the testing period." Please provide the estimated disposal costs for Franklin TN.	Provide the dry and wet tons of non-class A sludge that is anticipated to be generated during the testing period. Provide detailed plans for landfill disposal, and a contingency plan for sludge that doesn't pass the landfill's disposal requirements.

Item	Paragraph	Question/Comment	Response
2	01025A-9, 2.08	As part of the bid scope, the Supplier is to include payment, performance and warranty bonds. Typically, specifications requiring such bonds for protection of the Owner, request a pre- qualification letter from the bonding agency to be submitted with the bid to verify the supplier's bonding capacity can meet the bid requirements. Confirm a letter from the THP Supplier's bonding agency is to be submitted with the Supplier's bid submittal.	No, a pre-qualification letter does not need to be submitted with this proposal.
3	01322	Confirm photography and video is to be provided by the Contractor, as noted within Section 01664, 2.04.	Confirmed; all photography required for the project will be provided by the Contractor.
4	11351-5, 1.05.B	Per the specifications, Kruger understands the following services are to be provided: 10 days of Installation Supervision 10 days of Startup and Functional Testing 90 days of Commissioning 5 days of Overall THP O&M training 30 days of Intensive Acceptance Testing 60 days of 24/7 Optimization and Shadowing Please confirm that this support must be supplied by the THP supplier and/or equipment supplier directly and not an outside company. In the interest of the municipality, it is best for THP Supplier and/or equipment supplier to provide these services directly, as they hold the expertise. Please confirm.	Confirmed; this support must be supplied by the THP supplier and/or equipment supplier directly.

Item	Paragraph	Question/Comment	Response
5	11351-5, 1.05.B	During shadowing, confirm if the THP Supplier is to have someone operating the system (monitoring) and someone conducting training, or is the training to be completed entirely before the 60 optimization and shadowing is completed? We believe the intention of the specifications is for training to be done prior to acceptance testing and therefore the operation/shadowing period. Training should be completed prior to shadowing as the THP supplier will be responsible for maintaining proper operation during this time frame (solely responsible). Please confirm.	Confirmed; the training will be completed prior to the operation/shadowing period. Franklin WRF personnel may shadow the THP supplier representative during the 60 day optimization and shadowing period to achieve enhanced familiarity with the system. The THP supplier representative's primary responsible is to maintain proper operation of the system. The representative's secondary responsibility is to answer any questions a shadowing operator may have.
6	11351-22, 3.06.D	Please provide the values for $SD, $DIS and $REV to be used for evaluating the penalties associated with the Percent Volatile Solids Destruction. In addition, confirm the timeline in which this value will be implemented, if required (i.e. estimated over a 5 year period); this is currently undefined.	These values will be determined with the City of Franklin during the proposal evaluation period.
7	16000-22, 3.04 (General Electric)	Please confirm the service mentioned in 16000-22 3.04 (General Electric) is the responsibility of others.	Confirmed; the services of manufacturer's representatives for the items listed in paragraph 3.04.A are the responsibility of others.
8	Attachment D, Cost Items, 17 - One year service contract	Please confirm that this support must be supplied by the THP supplier and/or equipment supplier directly and not an outside company. Manufacturer services such as these are typically provided directly by the equipment supplier as they hold the expertise. Please confirm.	Confirmed; this support must be supplied by the THP supplier and/or equipment supplier directly.
9	General Comment	The spec does not state the required time for detailed design workshop. Does CDM want this time included in the TH system supplier bid, or should this be addressed at a later date? If this is required during this bid, please provide the duration and extent of the design workshops.	Design coordination should be part of the bid price.
10	General Comment	Confirm that a letter from the THP Supplier's bonding agency is to be submitted with the Supplier's bid submittal.	See answer to question 2 above.

Item	Paragraph	Question/Comment	Response
11	11351-18, 2.10 – Cooling Heat Exchangers	While we understand that no redundant cooling heat exchanger (HE) has been required by the specifications, injecting FOG will cause fouling that has not been accounted for in the design with only one HE. The fouling is independent of the type of processes (i.e., continuous or batch). We suggest that a fully redundant cooling HE be required as part of the design to account for the maintenance and associated downtime of the cooling HE when injecting the FOG prior to the cooling HE. Please change Section 11351 to require a redundant HE.	A fully redundant heat exchanger is not required; please provide heat exchangers as described in the response to question 38 in Addendum No. 2. Per specification 15754, paragraph 1.01.C.L, the hydrolyzed sludge (combined thermally treated WAS and FOG) will be diluted by recirculated digested sludge upstream of the cooling heat exchangers. The flow rate of digester sludge required is based on the larger value of the below parameters: 1. Maintain a minimum 5.0 feet/second velocity through the cooling heat exchangers' 4-inch diameter sludge piping. 2. Provide minimum digester sludge to hydrolyzed sludge ratio of 4:1. This dilution is designed to discourage fouling of the heat exchangers.
12	Cover Letter	The RFP cover letter indicates that 2 hardcopies and an electronic copy are required. Additionally, the RFP cover letter indicates that transmittal via FTP upload is acceptable. Can you please provide FTP upload instructions as Cambi's proposal will likely exceed email file size limitations? Would it be acceptable to receive hardcopies on Monday, Nov 3 provided that the electronic version is received prior to 5 pm EST on Oct 31? Due to the nature of the changes incorporated in Addendum 2, it will be difficult to mail hardcopies on Thurs for delivery on Friday.	Complete electronic proposals should be uploaded to the THP System Supplier's or their local representative's FTP site, or an alternative such as Dropbox, no later than the above listed deadline for proposals. An e-mail containing detailed login instructions for retrieving the proposal files must also be received by the Engineer no later than the deadline. Provided that the files are posted and the retrieval instructions are received by the Engineer before the deadline, it will be acceptable to deliver paper copies of the proposal to the Engineer no later than the close of business on Monday, November 3, 2014.

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