INDEX TO

SECTION 02668 – PREFABRICATED BOOSTER PUMP STATION

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PREFABRICATED BOOSTER PUMP STATION

PART 1 – GENERAL

1.1 DESCRIPTION

The work covered by this section consist of furnishing pumps, skid, VFD and controls from single source. The pumping system manufacturer shall design, furnish, deliver and warranty complete factory built system with all necessary piping, controls and appurtenances as mentioned in this specification and the contract.

The pumping station shall include five (5) pumps in appropriate metallurgy with premium efficiency electric motors, variable frequency drive unit and controllers as needed. The pumps, variable speed drive and controller shall be manufactured by a US manufacturer pre-approved by owner and engineer to ensure system component compatibility. For drinking water services, the unit will include components, materials, coatings certified to NSF61 safe for Drinking Water. Package will be UL-NSF listed, as required.

The manufacturer shall provide necessary start-up and training through factory trained authorized representative, if included in offering.

1.2 WORK INCLUDED

A. Packaged Pumping System

B. Centrifugal pumps manufactured by the pumping system manufacturer.

C. Pump Controls system

1. Control Panel
2. Variable Frequency Drive
3. Electrical Installation
4. Sequence of Operation
5. Low Flow Stop Function

D. Single skid base with pumps, piping, valves and fittings.

E. Sensor transducers and gauges

1.3 MEASUREMENT AND PAYMENT

A. Prefabricated Booster Pumping System: No unit measurements will be made for the Prefabricated Booster Pumping System, payment will be made at the lump sum price for "Prefabricated Booster Station – Complete, in service". Includes pumps, motors, piping, valves, skid, crane, and all appurtenances required to complete a full operational system.

1.4 REFERENCE STANDARDS

The work in this section is subject to the requirements of applicable portions of the following standards:

A. AWWA – American Water Works Association Hydraulic Institute
B. ANSI – American National Standards Institute
C. ASTM – American Society for Testing and Materials
D. HI – Hydraulic Institute
E. ASME – American Society of Mechanical Engineers
F. IEEE – Institute of Electrical and Electronics Engineers
G. NEMA – National Electrical Manufacturers Association
H. NEC – National Electrical Code
I. ISO – International Standards Organization
J. UL – Underwriters Laboratories, Inc.
K. IEC – International Electrotechnical Commission
L. NSF – NSF International

1.5 SUBMITTALS

A. Submittals shall include the following:
   1. Piping and Instrumentation Diagram (P&ID)
   2. Packaged System General Arrangement Drawing
   3. Electrical On-Line Diagram
   4. Equipment Approval Check List
   5. Control Wiring Diagrams
   6. Sequence of Operations
   7. Pump Data Sheets or Catalog Sheets
   8. Motor Data Sheets or Catalog Sheets
   9. Valves Data Sheets or Catalog Sheets
   10. Instrumentation Data Sheets or Catalog Sheets

B. Submittals must be specific to this project. Generic submittals will not be accepted. Components listed in this specification are subject to change based on availability. A like component will be substituted and submitted for information when required.

1.5 QUALITY ASSURANCE

A. The pumping package shall be manufactured and assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer. The manufacturer shall assume "Unit Responsibility" for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all project system components supplied by the pumping system manufacturer. Further, to ensure system responsibility, the pump package manufacturer must also be the manufacturer of the pumps, the controller(s), the VFD's (if applicable), and the controls. Pumping package assemblers who do not manufacture the pumps and/or the controllers/controls will not be considered equal nor acceptable

B. The manufacturer shall have a minimum of 10 years' experience in the design and construction of packaged pumping systems.

C. Bidders shall comply with all sections of this specification relating to packaged pumping systems. Any deviations from this specification shall be bid as a voluntary alternate clearly defined in writing. If no exceptions are noted, the supplier or contractor shall be bound by these specifications.

D. The packaged system manufacturer (Vendor) shall construct the equipment in an ISO 9001-2008 certified facility.

E. The packaged system manufacturer (Vendor) shall have a NSF61 certificate on the packaged system.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with these specifications, the following manufacturers shall be acceptable:

1. Grundfos
2. Syncroflo
3. Pre-Approved Equal.

2.2 MANUFACTURED UNITS

A. Furnish and install as shown on the plans a Packaged Pumping System as manufactured by Grundfos, Syncroflo or approved equal. Pumps shall be capable of delivering at design condition total 11,111 gpm @ total dynamic head (TDH) of 46 psi at 1800 rpm maximum rpm. Total system losses are not considered in overall performance and may vary per installation. Pumped liquid will be water at a temperature of 68 Deg F. System to achieve total flow capacity using five (5) number of pumps.

B. The pumps and motors shall be suitable for operating under the following design conditions:

Design Option #1:

Pump No.	GPM	TDH	HP	RPM	EFF
1, 2	1042	106' (46 PSI)	60	1800	83
3, 4, 5	3300	106' (46 PSI)	125	1780	89
X (Future)					

Design Option #2:

- Minimum Inlet Pressure: 40 psig
- Estimated Internal Losses: 10 feet.
- System Discharge Pressure: 88 psig.

Pump No.	Duty Point	Pump TDH	% Efficiency	Horsepower	RPM
1	1600 GPM	120'	85%	60	1780
2	1600 GPM	120'	85%	60	1780
3	3500 GPM	120'	86%	125	1780
4	3500 GPM	120'	86%	125	1780
5 (Future)	3500 GPM	120'	86%	125	1780

C. The packaged pump system shall include, pump & motor assemblies, microprocessor based pump controller, variable frequency drive(s), suction and discharge piping and additional equipment as specified. Pressure transducers shall be mounted on the package headers.

D. Provide pumps as indicated on the pump schedule. Pumps and motors shall be furnished as specified in respective sections of this document.

E. The suction and discharge of each pump shall be fitted with an isolation valve so that the pump can be serviced while system is still operational. The discharge of each pump will be fitted with a check valve.

F. Piping and valves shall be sized to maintain a maximum fluid velocity of 10 ft/sec for discharge headers.

G. System shall require only user interface piping connections for suction and discharge headers, relief valves or flow meters where applicable. Electrical requirements may be single point power or multiple connections as required for the site.

H. Pressure gauges and transducers shall be installed on the suction and discharge headers with isolation ball valves.

I. One sampling tap shall be installed on the discharge header, as shown on the Plans and per Georgia EPD requirements.

J. All components including pumps, piping and controls shall be mounted and shipped as a single unit. Controls may be shipped loose due to size or as directed.

2.3 COMPONENTS

A. PUMPS – DESIGN OPTION #1

2.3.1 VERTICALLY MOUNTED SPLIT COUPLED SPLIT-CASE PUMPS

a. Furnish and install vertically mounted split coupled, split-case pumps as per plans and pump schedule.

b. The pump, stand, coupling, and electric motor shall be factory assembled at the pump manufacturer's facility. The pump manufacturer shall have complete unit responsibility.

2.3.1.1 PUMPS

a. The pumps shall be split coupled, vertical mounted, single stage, double suction, between bearing, axial split case design, in cast iron or ductile iron bronze fitted construction specifically designed for quiet operation.

b. Pumps shall have the casing divided on the vertical centerline. The casing halves shall be accurately machined, bolted and doweled together. A non-asbestos type gasket material shall be furnished between the casing halves. The casing material shall be close-grained cast iron ASTM A48 - Class 35 with a minimum tensile strength of 35,000 P.S.I. Pumps shall be fitted with lead-free bronze renewable case wear rings indexed with a dowel pin for fixed positioning. Removal of the upper casing half and bearing housings shall permit removal of the complete rotating assembly without disturbing piping connections or motor. Volute shall have integrally cast support feet, gauge ports at nozzles, and vent and drain ports. Pumps with larger than 4-inch discharge flanges shall be of the double volute design extending to both upper and lower half of the casing. Casings shall be designed for scheduled working pressure and shall be hydrostatically tested at 150% of the maximum working pressure under which the pump could operate at design speed. Suction and discharge flanges shall be drilled to ANSI Standards and be machined flat face. Flanges shall be extra heavy-duty design and will be of 250# thickness while capable of being drilled for 125# ANSI flat face use.

c. Pumps shall be provided with removable upper and lower bearing housings which will permit inspection and/or replacement of the mechanical seal and bearing without removing the rotating assembly or upper half of the casing. Straightening vanes shall be cast in both the bearing housings and casing to reduce pre-rotation of fluid prior to entry into the impeller.

d. The upper and lower bearing housings shall be removable and supply support for the sleeve bearing, with required provision for purging or flushing. The pump shaft shall be adequately supported by the pump bearings to limit the shaft deflection to 0.008 inches. Sleeve bearings shall be Graphalloy material. Each bearing housing shall be bolted to the upper and lower casing

halves for a full 360-degree support registered fit to insure positive alignment.

e. The pump shaft shall be of solid AISI 416 stainless steel without sleeves.

f. The pump manufacturer shall recommend the proper mechanical seal based on the pressure, temperature and liquid outlined on the equipment schedule. Mechanical seals, at a minimum, shall have ceramic stationary seats, carbon rotating seats, Buna elastomers and stainless steel hardware. The mechanical seal and bearings shall have external flushing lines. Seals shall be capable of being inspected and easily replaced without removing the upper half of the casing. The pump shall have no mechanical seal at the bottom, for easy maintenance.

g. Impeller shall be of the enclosed Francis Vane type, double suction design, made of aluminum bronze, ASTM B148 UNS C95400, both hydraulically and dynamically balanced to ISO 1940-1:2003 balance grade G6.3 and keyed to the shaft. The impeller shall be trimmed to meet the specific hydraulic requirements.

h. Pump shall be connected to the drive motor by a rigid, aluminum, axially split coupling capable of withstanding all torsional, radial and axial loads. The coupling design shall facilitate alignment of the motor and pump shaft.

i. The pump shall be supported from below by a cast iron, ductile iron, or fabricated steel mounting stand, which shall be bolted directly to the bottom of the casing and fully support the weight of the complete pump and motor. Supporting the casing from the side or top shall not be required, nor allowed.

j. Pump rotation shall be clockwise or counter-clockwise as viewed from the pump's motor end.

k. Pump shall be of a maintainable design for ease of maintenance and should use machine fit parts, which are easily disassembled.

l. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 1.1-1.5, section 1.4.6.1.1 for recommended acceptable unfiltered field vibration limits (as measured per HI 1.4.6.5.2, Figure 1.108).

m. Each pump shall be painted with one coat of high quality factory approved paint and name-plated before shipment from the factory.

n. Pump manufacturer shall be ISO-9001 certified.

o. Standard Pump Construction

- Volute: Cast iron ASTM A 48 – Class 35
- Case wear ring: Lead-Free Bronze, ASTM B584-90500
- Impeller: ASTM B148 UNS C95400
- Shaft: AISI 416 stainless steel
- Mechanical Seal: Carbon–Ceramic with Buna elastomers and stainless steel hardware
- Bearings: Sleeve bearing- Graphalloy
- Optional special material shall be available based on requirements

2.3.1.1.1 MOTORS

a. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned.
b. Motors shall be suitably sized per ISO5199 and shall meet NEMA specifications and conform to the standards outlined in EISA 2007.

2.3.2 INSTALLATION

The pump shall be installed per manufacturer's recommendations and according to the standards of the Hydraulics Institute.

2.3.3 TESTING

Where noted on schedule, pumping equipment may require the following:

- Certified Performance test
  The testing shall be in accordance with Hydraulic Institute level B or the latest HI standard as noted in the pump schedule.

2.3.4 WARRANTY

The warranty period shall be a non-prorated period of 12 months from date of installation, not to exceed 18 months from date of manufacture. Warranty shall cover against defective material and/or faulty workmanship.

B. PUMPS – DESIGN OPTION #2

2.3.1 END SUCTION CENTRIFUGAL PUMPS

a. Furnish and install horizontal close coupled end suction centrifugal pumps with flow and head as defined in this Section.

b. The pump, stand, coupling, and electric motor shall be factory assembled at the pump manufacturer's facility. The pump manufacturer shall have complete unit responsibility.

2.3.2.1 PUMPS

a. The pumps shall be horizontal close coupled end suction centrifugal pumps with flow and head as defined below. The pumps shall be manufactured according to the standards of the Hydraulic Institute and to ANSI specification No. B58.1. The pump casing material shall be ASTM A48, class 30, cast–iron capable of hydrostatic test @ 150% of maximum discharge pressure. The pump shall have replaceable suction and hub

wear rings. All mating parts shall have a register fit to ensure alignment.

b. The impeller shall be an enclosed, single piece casting, from ASTM B505, B148, B271, UNS C95800 lead free nickel-aluminum bronze and shall be completely machined on all outside surfaces and dynamically balanced at time of pump assembly. The impeller shall be keyed to the shaft and securely fastened with a vibration resistant lock screw and washer.

c. Casing wear rings shall be the same lead free nickel-aluminum bronze as the impeller.

d. The packing box shall contain a mechanical seal for the specific application.

e. Mechanical seal shall be equivalent to John Crane, type 21 standard seal.

f Rotary seal shall be from carbon.

g. Stationary seat shall be from ceramic.

h. Metallic parts shall be from 316 stainless steel.

i. Elastomeric parts shall be from Buna–N.

j. The impeller shall not contact the suction or hub wear ring under any operating load condition.

k. The pump and motor shall be connected by an ASTM 48 class 30, cast–iron bracket incorporating a full isolating shield with neoprene slinger ring to prevent moisture from entering the front motor bearing.

l. Pumps with suction and discharge connections shall have flanges conforming to the flange pattern of ANSI 125 psi flanges.

m. Pump volutes shall be “Double Volute” type with external casing ribs in the casting.

n. Maximum pump suction pressure shall be 100 PSIG at 250°.

o. Maximum working pressure shall be no less than 175 PSIG at 250°.

p. The pump shall be as manufactured by Cornell or Gould’s.

q. The pumping systems manufacturer shall have a network of service centers which shall have available spare parts and trained pump technicians to handle service, repair and warranty procedures.

2.3.2.1.1 MOTORS

a. Motor enclosure shall be TEFC, TCZ frame, premium efficient.

b. Motor shall have a 1.15 service factor, class F insulation, and 95% full load efficiency.

c. Motors shall be inverter ready, wound for 3/60/460 Volt full voltage starting.

d. Maximum pump horsepower shall not be greater than motor nameplate rating exclusive of service factor.

e. The motor shaft shall be high–strength steel protected by a 416 stainless steel shaft sleeve secured to the shaft.

f. Motor frames shall be cast iron with steel end bells and conduit boxes.

g. Motors shall be "Super E" type as manufactured by Baldor.

2.3.3 INSTALLATION

The pump shall be installed per manufacturer's recommendations and according to the standards of the Hydraulics Institute.

2.3.5 TESTING

Where noted on schedule, pumping equipment may require the following:

- Certified Performance test
  The testing shall be in accordance with Hydraulic Institute level B or the latest HI standard as noted in the pump schedule.

2.3.6 WARRANTY

a. The manufacturer shall warrant that the water pumping system shall be free of defects in workmanship for a period of one year from date of authorized start–up but not to exceed eighteen months from date of manufacturer's delivery to the site.

b. Provided that all installation and operation responsibilities have been properly performed, manufacturer shall provide a replacement part or component during the warranty life. Any repairs to be accomplished at manufacturer's expense must be pre–authorized. The start–up certificate must be on file with manufacturer to activate warranty. Upon request, manufacturer shall provide advice for trouble shooting of a defect during the warranty period.

c. Manufacturer shall use only first quality material. As with any mechanical or electrical device, some preventive maintenance efforts are required to assure an adequate service life. A periodic preventive maintenance program recommendation shall be included in the owner's manual. Manufacturer shall support a large

national network of technical service technicians. Manufacturer's field service technicians shall be contacted for service.

C. CONTROL PANEL AND PUMP SYSTEM CONTROLS (W / PANEL MOUNTED DRIVES AS NEEDED)

1. Control Panel:

1.1 All power and controls components including the controller, HMI, VFD's, and other electrical components shall be housed and mounted in UL Type 12 rated enclosures (or others as required per site specification). A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly and warranted by the pump station manufacturer. All equipment and wiring shall be mounted within the enclosure and each device shall be labeled for proper identification. A complete wiring circuit diagram and legend with terminals, components, and wiring completely identified shall be provided. The control panel shall include a main disconnect, branch circuit protection for each pump-motor and the control circuit and control relays for alarm functions.

Control panel shall include as standard:

- Main Disconnect Switch
- Service Disconnect Switches (External / Lockable)
- Alarm Circuit
- System Fault Light
- Pump Run Light
- Surge Arrestor

1.2 All control enclosures and controls shall have been manufactured on the pumping system manufacturer's site by the pumping system manufacturer.

1.3 One properly sized cooling fan and exhaust vent shall be provided for each VFD.

1.4 In order to assure complete system integration, Manufacturer, without exception, shall maintain a fully equipped UL and ETL authorized panel shop at his facility under the same roof as the fabrication, painting, and assembly of the mechanical components.

1.5 Manufacturer, without exception, shall be authorized by Underwriters' Laboratories to label its manufactured control panels as UL Listed under category NITW/NITW7.

1.6 Manufacturer, without exception, shall conform to the latest edition of NFPA 70 in the manufacturing of its control panels.

1.7 The control enclosures shall be constructed of 12 gauge steel and the back plate assembly shall be constructed of 12 gauge steel.

1.8 Pump run lights, pump selector switches, the general alarm light, the reset button, and the touch screen shall be mounted on an enclosure door. All of these components and shall be rated NEMA 4.

1.9 All internal components shall be mounted and secured to the removable back plate assembly. All equipment and wiring shall be mounted within the enclosure and labeled for proper identification.

1.10 All adjustments and maintenance shall be able to be done from the front of the control enclosure.

1.11 A complete wiring circuit and legend with all terminals, components, and wiring identification shall be provided.

2. Pump System Controller

2.1 The pump system controller shall be a standard product developed and supported by the pump manufacturer. The design of the pump system controller(s) shall be the responsibility of the manufacturer and shall account for low- and high-flow operation.

2.2 The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller shall provide data entry and read-out capabilities. The controller user interface shall have a color display with a minimum screen size of 3-1/2" x 4-5/8" OR a 10.1" high-definition widescreen graphic touch screen for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.

2.3 The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

2.4 The controller shall have the ability to be connected to a battery to maintain power on controller during periods of loss of supply power.

2.5 The controller shall have built in data logging capability. Logged values shall be graphically displayed on the controller and able to be exported to computer via standard connection. A minimum of 3600 samples per logged value with the following parameters available for logging:

a. Estimated flow-rate
b. Total gallons pumped
c. Gallons pumped per day history

d. Speed of pumps
e. Pump starts and run hours and system status indicators
f. All alarms and alarm history
g. Inlet pressure
h. System discharge pressure
i. Power consumption
j. Controlling parameter (process value)
k. Automatic and digital manual adjustment speed control
l. Pressure, flow, speed, calibration, time, and clock settings

2.6 The controller shall display the following as status readings from a single display on the controller (this display shall be the default):

a. Current value of the control parameter, (typically discharge pressure)
b. Most recent existing alarm (if any)
c. System status with current operating mode
d. Status of each pump with current operating mode and rotational speed as a percentage (%)
e. Estimated flow-rate not requiring flow meter connection (discharge sensor and predicted pump curve required)

2.7 The controller shall have hardware inputs and outputs that shall be compatible with the manuafcturer's system, and as a minimum include the following:

a. Three analog inputs (4-20mA or 0-10VDC)
b. Three digital inputs
c. Two digital outputs
d. Ethernet connection
e. Field Service connection to PC for advanced programming and data logging

2.8 Pump system programming (field adjustable) shall include as a minimum the following:

a. Water shortage protection (analog or digital)
b. Transducer Settings (Suction and Discharge Analog supply/range)
c. PI Controller (Proportional gain and Integral time) settings
d. High system pressure indication and shut-down
e. Low system pressure indication and shut-down
f. Low suction pressure/level shutdown (via digital contact)
g. Low suction pressure/level warning (via analog signal)
h. Low suction pressure/level shutdown (via analog signal)
i. Flow meter settings (if used, analog signal)

2.9 The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).

2.10 All pumping system shutdowns shall be of the controlled type which gradually ramps down sequences pumps off.

2.11 The controller shall have advanced water shortage protection. When analog sensors (level or pressure) are used for water shortage protection, there shall be two indication levels. One level is for warning indication only (indication that the water level/pressure is getting lower than expected levels) and the other level is for complete system shut-down (water or level is so low that pump damage can occur). System restart after shut-down shall be manual or automatic (user selectable).

2.12 The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).

2.13 The controller shall be able to adjust the ramp time of a change in set point on both an increase or decrease change in set point.

2.14 The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

a. High System Pressure
b. Low suction pressure (warning and alarm)
c. VFD trip/failure
d. Loss of remote set-point signal (4-20mA)
Low system pressure
Individual pump failure
Loss of sensor signal (4-20 mA)
System power loss

2.15 The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor (typically discharge pressure).

2.16 The controller shall have a pump "Test Run" feature such that pumps are switched on during periods of inactivity (system is switched to the "off" position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (3-4) seconds every 24 hours, 48 hours or once per week and at specific time of day (user selectable).

2.17 The controller shall be capable of changing the number of pumps available to operate or have the ability limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.

2.18 The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

2.19 The controller shall be capable of displaying instantaneous specific energy use (kw/gpm), (optional flow meter must be connected).

2.20 The actual pump performance curves (5th order polynomial) shall be loaded (software) into the pump system controller or be able to input manually into controller based on three points on pump curve of pumps controlled.

2.21 The controller shall be capable of displaying an estimated flow-rate on the default status screen.

2.22 The controller shall have the ability to communicate common field-bus protocols (BACnet, Modbus, Profibus, or Ethernet IP and LON), via optional communication expansion card installed inside controller.

2.23 The controller shall have a built in Ethernet connection allowing controller to connected to network and access of controller via web browser and internet anywhere around the world where internet communication is available.

2.24 All operating variables, totals, operating status, alarms, and history within the controller will be made available to the SCADA provider as desired.

2.25 The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

3. Variable Frequency Drives

3.1 The VFD shall convert incoming fixed frequency single-phase or three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC induction motors. The VFD shall be a six-pulse input design, and the input voltage rectifier shall employ a full wave diode bridge; VFD's utilizing controlled SCR rectifiers shall not be acceptable. The output waveform shall closely approximate a sine wave. The VFD shall be of a PWM output design utilizing current IGBT inverter technology and voltage vector control of the output PWM waveform.

3.2 The VFD shall include a full-wave diode bridge rectifier and maintain a displacement power factor of near unity regardless of speed and load.

3.3 The VFD shall produce an output waveform capable of handling maximum motor cable distances of up to 1,000 ft. (unshielded) without tripping or de-rating.

3.4 The VFD shall utilize an output voltage-vector switching algorithm, or equivalent, in both variable and constant torque modes. VFD's that utilize Sine-Coded PWM or Look-up tables shall not be acceptable.

3.5 VFD shall automatically boost power factor at lower speeds.

3.6 The VFD shall be able to provide its full rated output current continuously at 110% of rated current for 60 seconds.

3.7 An empty pipe fill mode shall be available to fill an empty pipe in a short period of time, and then revert to the PID controller for stable operation.

3.8 Switching of the input power to the VFD shall be possible without interlocks or damage to the VFD at a minimum interval of 2 minutes.

3.9 Switching of power on the output side between the VFD and the motor shall be possible with no limitation or damage to the VFD and shall require no additional interlocks.

3.10 The VFD shall have temperature controlled cooling fans for quiet operation, minimized internal losses, and greatly increased fan life.

3.11 VFD shall provide full torque to the motor given input voltage fluctuations of up to +10% to -15% of the rated input voltage.

3.12 The VFD shall provide internal DC link reactors to minimize power line harmonics and to provide near unity power factor between each VFD and its circuit breaker. The line reactors shall be the high Z type with 5% impedance. The line reactors shall be rated for 480 nominal operating voltage.

3.13 VFD to be provided with the following protective features:

a. VFD shall have input surge protection utilizing MOV's, spark gaps, and Zener diodes to withstand surges of 2.3 times line voltage for 1.3 msec.

b. VFD shall include circuitry to detect phase imbalance and phase loss on the input side of the VFD.

c. VFD shall include current sensors on all three-output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

d. VFD shall auto-derate the output voltage and frequency to the motor in the presence of sustained ambient

temperatures higher than the normal operating range, so as not to trip on an inverter temperature fault. The use of this feature shall be user-selectable and a warning will be exported during the event. Function shall reduce switching frequency before reducing motor speed.

e. VFD shall auto-derate the output frequency by limiting the output current before allowing the VFD to trip on overload. Speed can be reduced, but not stopped.

f. The VFD shall have the option of an integral RFI filter. VFD enclosures shall be made of metal to minimize RFI and provide immunity.

3.14 VFD to be provided with the following interface features:

a. VFD shall provide an alphanumeric backlit display keypad, which may be remotely mounted using standard 9-pin cable. VFD may be operated with keypad disconnected or removed entirely. Keypad may be disconnected during normal operation without the need to stop the motor or disconnect power to the VFD.

b. VFD shall display all faults in plain text; VFD's, which can display only fault codes, are not acceptable.

c. All VFD's shall be of the same series, and shall utilize a common control card and LCP (keypad/display unit) throughout the rating range. The control cards and keypads shall be interchangeable through the entire range of drives used on the project.

d. VFD keypad shall be capable of storing drive parameter values in non-volatile RAM uploaded to it from the VFD, and shall be capable of downloading stored values to the VFD to facilitate programming of multiple drives in similar applications, or as a means of backing up the programmed parameters.

e. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

f. A start guide menu with factory preset typical parameters shall be provided on the VFD to facilitate commissioning.

g. VFD shall provide full galvanic isolation with suitable potential separation from the power sources (control, signal, and power circuitry within the drive) to ensure compliance with PELV requirements and to protect PLC's and other connected equipment from power surges and spikes.

h. All inputs and outputs shall be optically isolated. Isolation boards between the VFD and external control devices shall not be required.

i. There shall be three programmable digital inputs for interfacing with the systems external control and safety interlock circuitry. An additional digital input is preprogrammed for start/stop.

j. The VFD shall have two analog signal inputs. One dedicated for sensor input and one for external set point input.

k. One programmable analog output shall be provided for indication of a drive status.

l. The VFD shall provide two user programmable relays with selectable functions. Two form 'C' 230VAC/2A rated dry contact relay outputs shall be provided.

m. The VFD shall store in memory the last 5 faults with time stamp and recorded data.

n. The VFD shall be equipped with a standard RS-485 serial communications port for communication to the multi-pump controller. The bus communication protocol for the VFD shall be the same as the controller protocol.

3.15 VFD service conditions:

a. Ambient temperature operating range, -10 to 45ºC (14 to 113ºF).

b. 0 to 95% relative humidity, non-condensing.

c. Elevation to 1000 meters (3,300 feet) without derating.

d. VFD's shall be rated for line voltage of 525 to 690VAC, 380 to 480VAC, or 200 to 240VAC; with +10% to -15% variations. Line frequency variation of ± 2% shall be acceptable.

e. No side clearance shall be required for cooling of the units.

4. Electrical Installation

4.1 Electrical Design

a. All electrical material shall be UL Listed or recognized.

b. Conduit shall be nominally sized per NEC but shall not be less than ¾" minimum.

c. Flexible conduit is permitted to be ½".

d. External ground provisions shall be provided for all major equipment and main electrical devices (motors, control panels, power panels, transformers, disconnects, gutters, etc.)

e. Individual grounding shall be provided for each power circuit. Multiple grounds shall not be acceptable.

4.2 Electrical materials and installation for above skid finish surface and building electrical

a. EMT shall be provided and installed per NEC Article 358

b. Standard 4" x 11-1/2" 1900 boxes fittings shall be provided and installed per NEC Article 210, 220, and 314

c. XHHW wiring shall be sized, provided, and installed per NEC Articles 110, 300, 430, 695.

d. Wiring for control and power circuits (except electric motor circuits) shall be labeled on the end of each circuit with heat shrink type tagging. Motor circuit wiring shall be marked with phasing tape.

e. Flexible conduit and seal tight fittings shall be provided and installed per NEC Article 348 in runs up to 36".

f. Grounding shall be provided and installed per NEC Article 250

g. Electrical boxes and panels shall be NEMA 12 minimum.

h. Terminal strips shall be rated for 35A at 600V and shall be suitable for #26 AWG to #10 AWG wire size.

i. Transformer shall be general purpose dry type.

j. Load centers shall be QO, plug-on type panels.

k. Circuit breakers shall be plug-on type and provide protection for over current and short circuit.

l. Disconnects shall be general duty 3PH 600V devices and shall be NEMA 12 minimum enclosure.

m. Gutters shall be NEMA 12 minimum

n. Distribution blocks shall be 3-pole 600V and shall be 4 tap or 6 tap load side type

5. Sequence of Operation

5.1 The system controller shall operate equal capacity variable speed pumps to maintain a constant discharge pressure (system set-point). The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducer on the discharge manifold, indicating the actual system pressure. As flow demand increases the pump speed shall be increased to maintain the system set-point pressure. When the operating pump(s) reach 96% of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. When the system pressure is equal to the system set-point all pumps in operation shall reach equal operating speeds. As flow demand decreases the pump speed shall be reduced while system set-point pressure is maintained. When all pumps in operation are running at low speed the system controller shall switch off pumps when fewer pumps are able to maintain system demand.

5.2 The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.

5.3 All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

5.4 The system controller shall be able to control a pressure maintenance pump, (jockey pump), in the system. The set point of the pressure maintenance pump shall be able to be any value above or below the pump system's set point. The pressure maintenance pump shall be able to be staged on as back-up pump when capacity of pump system is exceeded.

6. Low Flow Stop Function

6.1 The system controller shall be capable of stopping pumps during periods of low-flow or zero-flow without wasting water or adding unwanted heat to the liquid. Temperature based no flow shut-down methods that have the potential to waste water and add unwanted temperature rise to the pumping fluid are not acceptable.

<u>Standard Low Flow Stop and Energy Saving Mode</u>
If a low or no flow shut-down is required (periods of low or zero demand) a bladder type diaphragm tank shall be installed with a pre-charge pressure of 70% of system set-point. The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When only one pump is in operation the system controller shall be capable of detecting low flow (less than 10% of pump nominal flow) without the use of additional flow sensing

devices. When a low flow is detected, the system controller shall increase pump speed until the discharge pressure reaches the stop pressure (system set-point plus 50% of programmed on/off band). The pump shall remain off until the discharge pressure reaches the start pressure (system set-point minus 50% of programmed on/off band). Upon low flow shut-down a pump shall be restarted in one of the following two ways:

6.2 Low Flow Restart: If the drop in pressure is slow when the start pressure is reached (indicating the flow is still low), the pump shall start and the speed shall again be increased until the stop pressure is reached and the pump shall again be switched off.

6.3 Normal Flow Restart: If the drop in pressure is fast (indicating the flow is greater than 10% of pump nominal flow) the pump shall start and the speed shall be increased until the system pressure reaches the system set-point.

2.4 SYSTEM CONSTRUCTION

A. Skid Base Structure

1. Materials

1.1 All skids shall be constructed of fabricated carbon steel.

1.2 All materials used in the construction of the skid base, equipment mounting provisions, and support materials shall be new.

1.3 All structural steel shapes, bars, plates shall be ASTM A36 grade meeting the requirements of ASTM A6.

1.4 All structural channel, I-beam, and square tubing provided as skid running members (main supports) shall be provided with MTR reports upon request at time of order.

2. Standards of Design

2.1 Load bearing beams shall be contained within and welded to a steel, I-beam or structural channel exterior.

2.2 Appropriate space and clearance shall be provided for access, operation, and maintenance of supplied equipment.

2.3 Unit will be constructed as open I-beam or C-channel base that shall be sized for the weight of the equipment being provided. Open frame design shall be filled with compactable material, finished with concrete, and sloped to drain by installing contractor. All equipment will be attached to main skid members and connected appropriately (including pump, driver, controller)

2.4 Lifting provisions shall be incorporated into the skid design. The preferred method of lifting provision shall be lifting lugs installed in the exterior running members of the skid structure.

3. Standards of Manufacture

3.1 All welded structural members, brackets, pipe supports, equipment supports, and racks will be completely seal welded. Plates may be stitch welded.

3.2 All structural welds will be performed by AWS D1.1 certified welders.

3.3 All welds shall be of high quality and ground clean. The welds shall be free of slag, pinholes, and undercut.

3.4 All major equipment shall be bolted to main skid structural members. Equipment may be installed on stands, risers, etc. No equipment may be attached to floor plate or light weight (less than ¼") angle brackets.

3.5 All skids shall be provided with two drilled and tapped grounding lugs located at opposite corners of the skid and seal welded to the exterior structural member web.

3.6 The measurement of the skid diagonal will fall within ¼" of the calculated value using the square root of the sum of the squares of the measured length and the measured width.

3.7 The main welded skid joints (4 corners) shall be liquid penetrant tested in accordance with ASTM E1417-95a, Standard Practice for Liquid Penetrant Examination Using Solvent Removable Process.

3.8 The lifting lugs shall be liquid penetrant tested in accordance with ASTM E1417-95a, Standard Practice for Liquid Penetrant Examination Using Solvent Removable Process.

B. Piping

1. Materials

1.1 All carbon steel pipe used in the system shall be a minimum schedule 20 ERW API5LX-52 or ASTM A53B grade material.

1.2 All piping, 10" and smaller, shall be constructed from ASTM A105 or ASTM A–53 schedule 40 pipe.

1.3 Piping greater than 10" shall be standard weight and conform to the same specification.

1.4 Piping 10" to 24" size shall be plasma cut and beveled, including ends, and side penetrations, on a single machine, capable of tilting, extending, and rotating the pipe for making three dimensional cuts.

All entrances and exits to the piping shall also be cut in this fashion. Machine shall cut manifolds and branches to be welded onto the manifolds, including any cuts that are not 90 degrees to the axis of the pipe.

1.5 Maximum velocity in manifolds shall be no greater than 10 feet per second (FPS).

1.6 Maximum velocity in branches 7.5 FPS.

1.7 Grooved piping fittings shall be cast iron, ductile iron, or carbon steel construction. Grooved fittings shall have a maximum allowable working pressure of 300 PSI or greater.

1.8 Flanged carbon steel fittings shall be Class 150 as appropriate for system working pressure.

1.9 Welders performing structural and pipe welds shall be certified to ASME section IX, and their certificates shall be on file with the manufacturer. Upon request by the engineer or owner, the certificates shall be made available for inspection.

1.10 After fabrication and before coating, piping shall be hydrostatically tested to 150% of maximum pump shutoff pressure plus stated suction pressure, or greater.

1.11 Fusion bonded epoxy shall be equivalent to 3M 134 FEBC.

1.12 Optional Materials For Drinking Water

a. Carbon steel as noted above with NSF61 Scotchkote 134HG coating on pipe interior.

2. Piping Supports

2.1 Piping support shall be manufactured from structural rectangular tubing, sized according to the weight and size of the piping to be supported.

2.2 Each tubing member shall be capped to prevent internal corrosion.

2.3 Vertical tubing members shall be solidly welded to the skid and shall support the weight of the piping when filled with water.

2.4 Horizontal tubing members shall be solidly welded to the vertical members, shall extend beyond the pipe OD, and shall support the weight of the piping when filled with water.

2.5 Piping shall be secured to the members through the use of piping U bolts designed for this purpose.

2.6 Thrust of the piping, whether the thrust is in the vertical or horizontal direction, shall be restrained on site by the installing contractor.

3. Standard of Manufacture

a. All pipe connection welds will be performed by ASME Section IX certified welders.

b. All welds shall be of high quality and ground clean. The welds shall be free of slag, pinholes, and undercut.

c. Piping and piping components shall be installed and supported to prevent excess strain as required by pump and valve manufacturers.

4. Piping designed for the removal of smaller pumps to be replaced with larger (future) pumps as the demand for water increases for this application.

C. Valves

1. Butterfly Valves

a. All butterfly valves shall be provided in the sizes shown on the pump station plan drawings. Included are the pump suction, discharge, and bypass isolation valves.

b. Valves shall be capable of bi-directional and end of line, drop tight service.

c. Valve shall have one piece ASTM A-536 ductile iron body.

d. Upper and lower shafts shall be 416 stainless steel.

e. Disc materials may be ASTM A-536 ductile iron with ENP plating or Nylon 11 coating or CF8M stainless steel or aluminum bronze.

f. Shaft seals shall be self–adjusting V-type with full length Nylatron bushings.

g. Seats shall be a replaceable one piece BUNA-N seal with a three groove fit to the body.

h. Manual actuators shall be of the traveling nut, self–locking type and shall be designed to hold the valve in any position intermediate between fully open and fully closed without creeping or fluttering. Hand wheel operators shall be provided.

i. Valves shall be rated at 150 PSI working pressure.

j. Valves shall be the BF Series as manufactured by Henry Pratt Company.

2. Ball Valves:

   a. Isolation valves from 1/4 inch to 1 inch sizes, shall full port ball valves.

   b. Valve shall be a two piece bronze full port ball valve rated at 300 PSI CWP.

   c. Valve shall have adjustable packing, blow–out proof stem, RPTFE seats and stuffing box ring, hardened ball, and actuator mounting pad.

   d. Stem and gland shall be from B16 bronze.

   e. Ball shall be chrome plated, from B16 bronze.

   f. Retainer and body shall be from B584–C84400 bronze.

   g. Body seal shall be from PTFE.

   h. Quarter turn manual actuator shall be from zinc plated steel, with Vinyl cover.

   i. Ball valve shall be as manufactured by American, Apollo, Conbraco, or Watts.

3. Grooved Couplings:

   a. A grooved coupling shall be provided in the suction piping of each pump with the sizes matching the suction valves shown on the pump station plan drawings.

   b. Grooved coupling body material shall be ASTM A536 ductile iron.

   c. Grooved coupling gasket material shall be NSF 61 approved EPDM.

   d. The grooved couplings shall be as manufactured Victaulic, Groove Lock, or Equal.

4. Check Valves:

   a. Check valves shall be provided on the discharge of each pump and in the bypass piping with the sizes shown on the pump station plan drawings.

   b. Check valve shall be globe body silent type. Check valves shall begin to close as forward velocity diminishes and shall be fully closed at zero velocity preventing flow reversal.

c. The valve body materials shall be ASTM A126, CLASS B cast iron and shall be lined with NSF approved fusion bonded epoxy.

d. The seat shall be lead-free bronze with a Buna–N insert for positive sealing to the disc.

e. The concave shaped disc materials shall be lead-free bronze.

f. Springs and retaining screw materials shall be T 316 stainless steel.

g. Bushing shall be as manufactured from lead free bronze.

h. Retaining screws shall be as manufactured from 316 stainless steel 9.

i. The valve design shall incorporate a center guided, spring loaded disc, guided at opposite ends, having a short linear stroke that generates a flow area equal to the pipe diameter.

j. Valves shall be sized to permit the design flow rates to pass through them without exceeding a pressure drop of 3 feet of water column. The check valves shall be rated at a maximum internal velocity of 10 FPS.

k. Check valves shall be rated at 150 psi working pressure.

l. Check valves shall be 1800 series as manufactured by Val–Matic.

D. Air Release Valves:

a. 1" air release valves shall be provide as shown on the pump station plan drawings. An isolation ball valve shall be provided upstream of each air release valve.

b. Air release valves shall have a ductile iron body, a stainless steel ball, and stainless steel trim.

c. Air release valves shall be rated at 300 psi working pressure with a 1/16 inch orifice.

d. Air release valves shall have a drop tight synthetic seat

e. Air release valves shall be model 22.9 as manufactured by Val–Matic.

E. Hose Bibs:

a. A hose bibb with vacuum breaker shall be installed on the suction and discharge headers.

F. Sensors and Gauges **(Factory Choice**)

1. A pressure transducer shall be factory installed on the discharge manifold (or field installed as specified on plans). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

2. A bourdon tube pressure gauge, 2.5 inch diameter minimum, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2-1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.

3. Transducers and Gauges shall include isolation shut-off valves to permit isolation and replacement of the component.

G. Overhead Crane

Overhead crane designed to lift 2 TONS (4,000lbs) welded to skid members. Crane designed for individual pump removal if required.

2.5 COATINGS: EQUIPMENT, STRUCTURAL STEEL, AND PIPING

1. All equipment that is provided within the packaged system should be supplied with the respective manufacturer's standard coating, unless otherwise noted. See Coating Specification No. 9000 for specific details.

2. Structural steel, piping, equipment support brackets and other packaged system items as necessary shall be protectively coated (RAL 9005 Black Low Gloss OR otherwise defined).

3. All steel piping shall be blasted inside to SSPC SP10, near white metal, and lined with an FDA/NSF 61 approved fusion bonded epoxy, meeting the requirements of AWWA Standard C213 and C550, tested and found to be without holidays. Fusion bonded epoxy shall be applied to the thicknesses required by AWWA Standards C213 and C550, and the manufacturer's recommendations regarding temperature, and duration. Manufacturer's certificate of application shall be retained on file, and shall be available for inspection when requested by the engineer or owner.

2.6 TESTING

The piping system shall undergo a factory hydrostatic test at the end of the production cycle. The piping system shall be filled with water and pressurized to 1.5 times the pump nameplate design pressure. The pressure shall be maintained for a minimum of 10 minutes with no leakage prior to shipment. Full system hydro-test can be offered if requested. Once package is installed at site, another hydrotest shall be required to ensure all bolts and fittings are tightly secured prior to startup (per installation instructions.

Electrical verification shall be performed at the factory, consisting of but not limited to proper function of lights, outlets, fans, dampers, AC units, and Controls operation. Grounded continuity testing and Hi-Pot testing on motor wiring shall be performed and recorded as part of the quality process.

2.7 WARRANTY

The manufacturer shall warrant the water pumping system to be free of defects in material and workmanship for one year (12 months) from date of authorized start-up, not to exceed eighteen (18) months from date of manufacturer's invoice. Complete terms and conditions will be provided upon request.

END OF SECTION