SECTION 43 21 15 – PUMPING SYSTEMS- HIGH SERVICE PUMPS

PART 1. GENERAL

Scope of Work

Furnish all labor, materials, equipment and incidentals required to install three (3) High Service Pumps as detailed below:
The High Service Pumps shall be manufactured by Grundfos Pumps Corporation (Model No. Hydro MPC-EC (CUE) 3CR 95-4-1, 3x460V 60Hz) or approved equal. 6" stainless steel piping will be provided on the high service pump skid.

Pump	Manufacturer	MODEL	Maximum Capacity (gpm)	TDH (ft)	Motor (HP)
HIGH SERVICE PUMPS – 3 (2 duty + 1 standby)	GRUNDFOS or approved equal	Hydro MPC-EC (CUE) 3CR 95-4-1 3x460V 60Hz	500 (EACH PUMP) 1,000 (SYSTEM)	310	60

Installation shall be complete and include, but not be limited to pumps, valves, controls, flanges, couplings, discharge pipe, and appurtenances as shown on the Contract Drawings and as specified herein

1.1 WORK INCLUDED

A. Variable Speed Packaged Pumping System

1.2 REFERENCE STANDARDS

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

A. Hydraulic Institute
B. ANSI – American National Standards Institute
C. ASTM – American Society for Testing and Materials
D. IEEE – Institute of Electrical and Electronics Engineers
E. NEMA – National Electrical Manufacturers Association
F. NEC – National Electrical Code
G. ISO – International Standards Organization
H. UL – Underwriters Laboratories, Inc.

1.3 SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00 Submittals:

Pre-Construction Submittals: The following shall be submitted in accordance with Section 01 33 00 Submittals:

Product Data: Submit product data for each component (pumps, motors, valves, instrumentation) describing equipment features, materials of construction, general dimensions, and operational parameters. Include detail specifications, available test data, and instructions for installation and maintenance.

Submit manufacturer's descriptive and technical literature, catalog cuts, performance charts, engineering data sheets, list of materials, and list of equipment. Provide flow and head information on pumps including suction lift that can be achieved by the pumps. Provide materials of construction for all piping systems. Provide pressure ratings for all piping. Include cut sheets and catalog data for piping, all instruments and relief valves.

Submit Shop Drawings for approval. Include:

a. Process flow diagram and process & instrumentation diagram for the skid.

b. Skid mounted system general arrangement showing dimensions, pipes, valves, instrumentation, appurtenances, weights elevations, and pipe sizes.

c. Include skid anchorage and mounting details, and clearances for maintenance and operation.

List of parts including size and material of construction for all pumps, motors, valves, instrumentation, and appurtenances.

d. Electrical wiring diagram for the control panel.

Informational Submittal

Skid delivery schedule.

Manufacturer’s test reports at manufacturing facility.

Recommended spare parts list

Contractor shall submit a Test Report describing the findings of the field inspection of the installed equipment and the results of the functional testing, hydrostatic testing, and performance testing – see paragraph 3.5 for details.

Operation and Maintenance Manual

Submit the operation and maintenance (O&M) manual and required number of copies in accordance with Section 01 78 23.

1.4 SEISMIC LOADS

The structural aspects of the system skid shall be sufficient to meet the Pennsylvania 2015 International Building Code requirements for Seismic Design Category = B.

1.5 DELIVERY AND STORAGE

Protect all equipment, delivered and designated for storage, from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.6 EQUAL PRODUCTS

The Contract Drawings and Technical Specifications are based on a conceptual arrangement of the systems and associated piping as shown on the Drawings and specified herein. Should the Contractor propose to furnish an equivalent system of a different configuration, the Contractor shall be responsible for all revisions necessary to incorporate the proposed system into the design and submit the necessary revised Contract Drawings and Technical Specifications for review and approval.

1.7 WARRANTY

A. The warranty period shall be a non-prorated period of 24 months from date of installation and 30 months from date of manufacture.

Part 2. PRODUCTS

2.1 VARIABLE SPEED PACKAGED PUMPING SYSTEM

A. Furnish and install a pre-fabricated and tested variable speed packaged pumping system to maintain constant water delivery pressure. The center line of pumps shall be at least 4-feet apart from each other and shall meet maintenance and cooling requirements.

B. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.

C. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.

D. The complete packaged pumping system shall be NSF61 Annex G listed for drinking water and low lead requirements.

2.2 PUMPS

A. All pumps shall be ANSI/NSF 61 Annex G listed for drinking water and low lead requirements.

B. The pumps shall be of the in-line vertical multi-stage design.

C. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

D. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 500 gallons per minute) shall have the following features:

1. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

2. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

3. Pump Construction.

a. Suction/discharge base, pump head	Ductile Iron (ASTM 65-45-12)
b. Shaft couplings, flange rings:	Ductile Iron (ASTM 65-45-12)
b. Shaft	431 Stainless Steel
c. Motor Stool	Cast Iron (ASTM Class 30)
d. Impellers, diffuser chambers, outer sleeve:	304 Stainless Steel
e. Impeller wear rings:	304 Stainless Steel
f. Intermediate Bearing Journals:	Tungsten Carbide
g. Intermediate Chamber Bearings:	Leadless Tin Bronze
h. Chamber Bushings:	Graphite Filled PTFE
I. O-rings:	EPDM

4. The shaft seal shall be a single balanced metal bellows cartridge with the following construction:

a. Bellows:	904L Stainless Steel
b. Shaft Sleeve, Gland Plate, Drive Collar:	316 Stainless Steel
c. Stationary Ring:	Carbon
d. Rotating Ring:	Tungsten Carbide
e. O-rings:	EPDM

5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

2.3 VARIABLE FREQUENCY DRIVES (Panel Mount)

A. 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.

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

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

D. 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.

E. VFD shall automatically boost power factor at lower speeds.

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

G. 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.

H. 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.

I. 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.

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

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

L. The VFD shall provide internal DC link reactors to minimize power line harmonics and to provide near unity power factor. VFD's without a DC link reactor shall provide a 5% impedance line side reactor.

M. VFD to be provided with the following protective features:

1. 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.

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

3. 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.

4. 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.

5. 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.

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

N. VFD to be provided with the following interface features:

1. 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.

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

3. 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.

4. 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.
5. 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.
6. A start guide menu with factory preset typical parameters shall be provided on the VFD to facilitate commissioning.
7. 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.
8. All inputs and outputs shall be optically isolated. Isolation boards between the VFD and external control devices shall not be required.
9. 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.
10. The VFD shall have two analog signal inputs. One dedicated for sensor input and one for external set point input.
11. One programmable analog output shall be provided for indication of a drive status.
12. The VFD shall provide two user programmable relays with selectable functions. Two form 'C' 230VAC/2A rated dry contact relay outputs shall be provided.
13. The VFD shall store in memory the last 5 faults with time stamp and recorded data.
14. 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.

O. VFD service conditions:

1. Ambient temperature operating range, -10 to 45ºC (14 to 113°F).
2. 0 to 95% relative humidity, non-condensing.
3. Elevation to 1000 meters (3,300 feet) without derating.
4. 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.
5. No side clearance shall be required for cooling of the units.

2.4 FIXED SPEED MOTORS

A. Fixed Speed Motors are to be provided with the following basic features:

1. Designed for continuous duty operation, NEMA design B with a 1.15 service factor.

2. Totally Enclosed Fan Cooled or Open Drip Proof with Class F insulation.

3. Nameplate shall have, as a minimum, all information as described in NEMA Standard MG 1-20.40.1.

4. Motors shall have a NEMA C-Flange for vertical mounting.

5. Drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump.

2.5 PUMP SYSTEM CONTROLLER

A. The pump system controller shall be a standard product developed and supported by the pump manufacturer.

B. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2" x 4-5/8" 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.

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

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

E. The controller shall have built in data logging capability. Logged vales 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:

- Estimated flow-rate
- Speed of pumps
- Inlet pressure
- Discharge pressure
- Power consumption
- Controlling parameter (process value)

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

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

G. The controller shall have as a minimum the following hardware inputs and outputs:

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

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

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

I. 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).

J. 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).

K. 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).

L. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

M. 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.

N. 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:

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

O. The pump system controller shall be mounted in a UL Type 12 rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.

Control panel options shall include, but not be limited to:

Pump Run Lights	System Fault Light
Audible Alarm (80 db[A])	Surge Arrestor
Emergency/Normal Operation Switches	Service Disconnect Switches

Qty (9) Configurable Digital Outputs available for monitoring

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

Q. 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).

R. 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.

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

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

U. 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.

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

W. The controller shall have the ability to compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates without the requirement of a flow meter.

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

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

Z. 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.

2.6 SEQUENCE OF OPERATION

A. 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.

B. 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.

C. 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.

D. 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.

2.7 LOW FLOW STOP FUNCTION

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.

Standard Low Flow Stop and Energy Saving Mode

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 (See specification 50 02 01 for bladder/hydropneumatics tank). 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:

A. 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.

B. 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.

Low Flow Stop and Energy Saving Mode

The pump system controller shall be capable receiving a digital signal from a flow switch or an analog signal from a flow meter to indicate a low flow condition. A bladder type diaphragm tank shall be

installed with a pre-charge pressure of 70% of system set-point (See specification 50 02 01 for bladder/hydropneumatics tank). The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When low flow is detected (signal from flow switch or meter), 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). The pump shall remain in the energy saving on/off mode during low flow indication. When low flow is no longer present (low flow indication ceases), the pump(s) shall resume constant pressure operation.

It shall be possible to change from the standard low flow stop to the optional low flow stop (and vice-versa) via the user interface.

2.8 SYSTEM CONSTRUCTION

A. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into manifold is not acceptable. Manifold construction shall be such that water stagnation can not exist in manifold during operation to prevent bacteria growth inside manifold.

B. The suction and discharge manifolds shall be constructed of 316 stainless steel. Manifold connection sizes shall be as follows:

3 inch and smaller:	Male NPT threaded
4 inch through 8 inch:	ANSI Class 150 rotating flanges
10 inch and larger:	ANSI Class 150 flanges

C. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy. The valve shall be provided with valve indicator and hand wheel operator. The valve shall be manufactured by Flowmatic, AWWA C504, Azure, Model 45 or equal.

D. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 2” and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat, spring material shall be stainless steel, and disk shall be of stainless steel. The check valve shall be a Model 888S6VFD, silent, wafer style, 316-SS, check valve manufactured by Flomatic or equal.

E. 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.

F. A bourdon tube pressure gauge, 2.5 inch diameter, 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.

G. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.

H. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and baseframe to minimize vibration.

I. Depending on the system size and configuration, the control panel shall be mounted on a 304 stainless steel fabricated skid, separate from the main system skid

2.9 TESTING

A. The entire pump station shall be factory tested for functionality. Functionality testing shall include the following parameters: Dry Run Protection, Minimum Pressure and Maximum Pressure alarms (where applicable), Setpoint Operation, and Motor Rotation.

B. The system shall undergo a factory hydrostatic test at the end of the production cycle. The system shall be filled with water and pressurized to 1.5 times the nameplate maximum pressure. Systems with 150# flange connections shall be tested at 350 psig, and systems with 300# flange connections shall be tested at 450 psig. The pressure shall be maintained for a minimum of 15 minutes with no leakage (slight leakage around pump(s) mechanical seal is acceptable) prior to shipment.

3.0 EXECUTION

3.1 GENERAL

The pumping system shall be manufactured in accordance with the best trade practices and in accordance with all applicable codes and regulations.

3.1 FABRICATION & SHIPMENT

The system supplier shall fabricate the entire skid as a pre-engineered skid in the factory in controlled conditions prior to shipping to the site.

The system supplier shall provide all installation documents and O&M Manuals in accordance with the contract documents.

3.2 INSTALLATION

Pumps, equipment, and appurtenances shall be installed to provide a complete and integrated system in accordance with the instruction of the system supplier and under the direct supervision of the system supplier's representative.

3.3 TESTING

After installation of each system, operating tests shall be carried out to assure that the system operates properly. If any deficiencies are revealed during any tests, such deficiencies shall be corrected, and the tests shall be re-conducted. Reports of all tests shall be submitted to the Owner’s Representative prior to final acceptance of the installation.

Pumps shall be tested at the site after installation to demonstrate that the pumps are capable of operating without any leakage and at the rated flows and pressures.

Test Report: Contractor shall provide a test report that shall include as a minimum a description of the test, methodology used, date and time when test was performed and the results of the testing. All testing results shall be reported, including test results that failed to meet the requirements. Should test runs fail to meet the requirements, an explanation shall be provided with the rationale for failure of the test.

Remedy: If the tests specified above reveals deficiencies, corrective measures shall be taken until the System satisfies all of the specified requirements. Remedies shall be completed at no additional cost to the Owner.

3.4 MANUFACTURER SERVICES

The Contractor shall provide the following personnel:

One (1) representative of the manufacturer who is experienced in the installation and adjustment of the equipment specified. The representative shall supervise the installation and adjustment of the equipment – for a minimum of 5 days (8 hours a day).

A representative of the Manufacturer for 10 days (3 trips) during Testing described in Paragraph 3.3.

Conduct a video recorded training course for designated operating, maintenance and support staff members. The training period shall be a total of 16 hours of normal working time. Field training shall cover each item contained in the operating and maintenance manual.

END OF SECTION