PART 1 – GENERAL

1.1 WORK INCLUDED

A. Vertical In-Line Multi-Stage Centrifugal Pumps.

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. IEC – International Electrotechnical Commission
E. IEEE - Institute of Electrical and Electronics Engineers
F. NEMA – National Electrical Manufacturers Association
G. NEC – National Electrical Code
H. NSF – National Sanitation Foundation
I. ISO – International Standards Organization
J. UL – Underwriters Laboratories, Inc.

PART 2 – PRODUCTS

2.1 VERTICAL IN-LINE MULTI-STAGE CENTRIFUGAL PUMPS

A. General Operating and Installation Characteristics

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

2. The pumps shall be ANSI/NSF 61 approved for drinking water.

3. 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.

4. Suction and discharge ports for pressure measurement shall be provided on request.

5. All pump bearings shall be lubricated by the pumped liquid.

B. Small Vertical In-Line Multi-Stage Pumps shall have the following features:

1. Pump Size and Range of Operation

a. Nominal flow rate shall range from 4.5 to 110 gallons per minute based on model group.

b. Pump base shall require no more than 1.5 square feet of floor space (including motor).

c. The suction/discharge base shall have ANSI Class 250 raised face flange or internal pipe thread (NPT) connections as indicated in the drawings or pump schedule.

d. Maximum working temperature shall be no less than 248 degrees F as standard and available for water up to 356 degrees F and thermal oil up to 464 degree F with optional air-cooled top arrangement.

e. The maximum working pressure shall be 362 psig and available up to 725 psig upon request.

2. Pump End Materials of Construction

   a. Standard Pump Materials

• Suction/discharge base, pump head, motor stool:	Cast iron, A 48-30 B
• Shaft:	Stainless steel, AISI 316 or 431
• Impellers, diffuser chambers, outer sleeve:	Stainless steel, AISI 304
• Impeller wear rings:	Stainless steel, AISI 304
• Shaft journals and chamber bearings:	Silicon carbide
• O-rings:	EPDM or FKM

   b. Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.

3. Pump Impeller Design

   a. Impellers shall be of the enclosed type with resistance spot-welded curved profiled blades and shall be secured directly to the pump shaft by means of a splined shaft arrangement.

   b. Impeller design characteristics shall be focused on achieving optimum pump hydraulic efficiency.

   c. The impeller stack shall have a modified design available for low NPSH inlet conditions.

4. Pump Thrust Compensation

   The axial thrust of the pump shaft during operation shall be compensated primarily by means of the drive motor fitted with angular contact bearings designed to handle the axial thrust load.

5. Pump Shaft Seal Design

   a. The shaft seal shall be of the cartridge type design.

   b. Standard shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. 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.

   c. Pump shall be available with options for double mechanical shaft seal or air-cooled seal chamber.

C. Large In-line Vertical Multi-Stage Pumps shall have the following features:

1. Pump Size and Range of Operation

   a. Nominal flow rate shall range from 140 to 340 gallons per minute based on model group.

   b. Each pump shall be designed for in-line installation requiring no more than 2.5 square feet of floor space (including motor).

   c. The suction/discharge base shall have ANSI Class 150 or Class 300 raised face flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

a. Maximum working temperature shall be no less than 248 degrees F as standard and available for water up to 356 degrees F and thermal oil up to 464 degree F with optional air-cooled top arrangement.

d. Maximum working pressure shall be no less than 362 psig and available up to 580 psig upon request.

2. Pump End Materials of Construction

a. Standard Materials of Construction

Suction/discharge base, pump head, motor stool:	Cast iron, ASTM 80-55-06
Flange rings:	Ductile iron, A 65-45-12
Shaft:	Stainless steel, AISI 431
Impellers, diffuser chambers, outer sleeve:	Stainless steel, AISI 304
Impeller wear rings:	Stainless steel, AISI 304
Intermediate bearing journals:	Silicon carbide
Chamber bushings:	Graphite filled PTFE
O-rings:	EPDM or FKM

3. Pump Impeller Design

a. The pump impellers shall be of the enclosed type with laser-welded, 3D-profiled blades and shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

b. Impeller design characteristics shall be focused on achieving optimum pump hydraulic efficiency.

c. The impeller stack shall have a modified design available for low NPSH inlet conditions.

4. Pump Thrust Compensation

The primary method of axial thrust compensation during pump operation shall be either:

a. The drive motor fitted with angular contact bearings designed to handle the axial thrust load.

Or

b. An external bearing flange mounted between the pump and the motor, in lieu of the motor being fitted with angular contact bearings

5. Pump Shaft Seal Design

    a. The shaft seal shall be of the cartridge type design.

    b. Standard shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. 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.

    c. Pump shall be available with options for double mechanical shaft seal or air-cooled seal chamber.

D. Extra Large In-line Vertical Multi-Stage Pumps shall have the following features:

1. Pump Size and Range of Operation

    a. Nominal flow rate shall range from 500 gallons per minute and larger based on model group.

    b. Pump base shall require no more than 12.0 square feet of floor space (including motor).

    c. The suction/discharge base shall have ANSI Class 150 or Class 300 raised face flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

    d. Maximum working temperature shall be no less than 248 degrees F as standard and available up to 356 degrees F for pumps fitted with motors up to 75 hp and equipped with optional air-cooled top arrangement.

    e. Maximum working pressure shall be 435 psig.

    f. The connection size shall be 6" or larger for nominal flow rates greater than 580 gpm.

2. Pump End Materials of Construction

    a. Standard Pump Materials

• Suction/discharge base, pump head, motor stool	Ductile cast iron, ASTM 70-50-05
• Shaft	Stainless steel, AISI 431 or 318 LN
• Impellers, diffuser chambers, outer sleeve	Stainless steel, AISI 304 or 316
• Intermediate bearing ring	Tungsten carbide/tungsten carbide
• Chamber bushings	Graphite filled PTFE
• O-rings:	EPDM or FKM
• Thrust handling device	316SS/silicon carbide/tungsten carbide

3. Pump Impeller Design

    a. The pump impellers shall be of the enclosed type with laser welded, profiled leading edge blades and shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

    b. Impeller design characteristics shall be focused on achieving optimum pump hydraulic efficiency.

4. Pump Thrust Compensation

Thrust compensation shall be accomplished by either:

a. The standard thrust compensation mechanism:

- For pumps fitted with a motor 75 hp or smaller, the axial thrust of the pump shaft during operation shall be compensated primarily by means of the drive motor fitted with angular contact bearings designed to handle the load so as not to compromise pump efficiency by hydraulically compensating for thrust in the impeller design.
- For pumps fitted with a motor 100 hp or larger, the axial thrust created by pump operation shall be borne primarily by a maintenance-free, thrust handling device of the thrust bearing type, as opposed to a piston type, which is lubricated and cooled by the pumped liquid and is located in the pump base.

Or

b. The axial thrust shall be borne primarily by an external bearing flange mounted between the pump and the motor.

5. Pump Shaft Seal Design

a. The shaft seal shall be of the cartridge type design.

b. Standard shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings and seal cover. Pumps shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

c. Pumps fitted with motors up to 75 hp shall be available with options for double mechanical shaft seal or air-cooled seal chamber.

2.2 MOTORS

A. Standard motors shall to be provided with the following basic features:

1. Motors must be C or D-faced directly coupled to the pump.

2. Motors shall be designed for continuous duty operation, NEMA design A or B with a service factor rating no less than 1.15.

3. Totally Enclosed Fan Cooled Motors are to be furnished with class “F” insulation. Open Drip Proof Motors are to be furnished with class “B” insulation.

4. Motor nameplate shall be mounted on enclosure with stainless steel fastening pins. Nameplate shall have, as a minimum, all information as described in NEMA Standard MG 1-20.40.1.

5. Open Drip Proof (ODP) motors shall have drip covers.

6. Motors over 50 lbs shall having lifting provisions to enable motor to be lifted from the pump end.

B. Integrated variable frequency drive motors shall be available in sizes from 1/2 hp to 30 hp as an alternative.

1. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) with a built-in pump system controller. The complete VFD/motor assembly shall be built and tested as one unit by the same manufacturer.

a. All motors 1 hp and above must meet or exceed IE3 efficiency level.

b. Motors from 1/2 hp to 15 hp shall be Permanent Magnet motor design, and 1 hp through 15 hp shall meet or exceed IE5 efficiency level.

c. Motors of 20, 25 and 30 hp shall be Asynchronous motor design.

d. The complete VFD/motor assembly shall be built and tested as one unit by the same manufacturer.

2. The VFD/motor shall have an IP55 (TEFC) enclosure rating as a complete assembly. The motor shall have a standard NEMA C-Face, Class F insulation with a Class B temperature rise.

3. The VFD shall be of the PWM (Pulse Width Modulation) design using up to date IGBT (Insulated Gate Bipolar Transistor) technology.

4. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of the motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

5. The VFD shall have, as a standard component, an RFI filter (Radio Frequency Interference) to minimize electrical noise disturbances between the power electronics and the power supply. The VFD/motor shall meet all requirements of the EMC directive concerning residential and light industry equipment (EN 61800-3).

6. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

7. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.

8. The VFD/motor shall include protection against input transients, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature.

9. The VFD/motor shall provide full nameplate output capacity (horsepower and speed) within a balanced voltage range of 414 to 528 volts.

10. <u>Automatic De-Rate Function</u>: The VFD/motor shall reduce speed during periods of overload allowing for reduced capacity pump operation without complete shut-down of the system. Detection of overload shall be based on continuous monitoring of current, voltage and temperature within the VFD/motor assembly.

11. The VFD/motor shall have, as a minimum, the following input/output capabilities:

    a. Speed Reference Signal: 0-10 VDC, 4-20mA
    b. Digital remote on/off
    c. Fault Signal Relay (NC or NO)
    d. Fieldbus communication port (RS485)

12. Motor 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 at full rated speed.

13. Pump System Controller and User Interface

    a. The pump system controller (Proportional-Integral) shall be a standard component of the integrated variable frequency drive motor developed and supported by the pump manufacturer.

b. The pump system controller shall have an easy to use interface mounted on the VFD/motor enclosure. Pump system start/stop and set-point adjustment shall be possible through the use of two push buttons located on the drive enclosure.

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

d. Pump status and alarm state shall be indicated via two LED lights located on the VFD/motor enclosure.

e. Advanced programming and troubleshooting shall be possible via a wireless hand-held programmer or a field connected personal computer. Pump system programming (field adjustable) shall include as a minimum the following:

System Pressure set-point, psig	System start pressure, psig
System Stop pressure, psig	Minimum Pump Speed, %
Pressure Transducer supply/range	Maximum Pump Speed, %
System Time (Proportional Gain)	Integral Action Time

f. The wireless programmer shall be capable of displaying the following status reading:

Pump Status (on, off, min., max.)	System Set-point, psig
Actual system pressure, psig	Remote set-point, %
Pump speed, rpm	VFD/Motor input power, kW
VFD/Motor total cumulative kWh	VFD/Motor total operating hours

g. The wireless programmer shall also be capable of displaying the following alarms, with the last five alarms stored in memory:

Loss of sensor signal	Loss of external set-point signal
Under-voltage & Over-voltage	Motor overload (blocked pump)
Motor over-temperature	Drive over-temperature
Drive Over-current	

14. Sequence of Operation

a. The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducer indicating the actual system pressure. When a flow demand is detected (system pressure drops below the start pressure) the VFD/motor shall start and increase speed until the actual system pressure matches the system set-point. As flow demand changes (increases or decreases), the speed of the pump shall be adjusted to maintain the system set-point pressure.

b. If a no flow shut-down is required (periods of zero demand), a bladder type diaphragm tank shall be installed. The tank shall be downstream of the pump. When zero flow is detected by the system controller, the pump shall be switched off. When the system pressure drops to the start pressure, (flow begins after shut-down), the pump shall be switched on, increasing speed to maintain the system set-point pressure. Zero flow conditions shall be detected by the system controller/factory installed pressure transmitter without the use of additional flow switches or motor current sensing devices.

2.3 TESTING

A. The pump manufacturer shall perform non-witnessed testing (in accordance with ISO9906; 2012, ANSI/HI 14.6 Grade 3B) of all pumps prior to shipment.

1. A two-point, pass/fail test of pump performance shall be conducted:

a. One test condition shall measure head developed at pump best efficiency point (BEP).

b. The other test condition shall measure head developed in a no flow test at pump shut-off.

2. A hydrostatic test shall be conducted at a pressure not less than 1.5 times the nameplate maximum operating pressure of the pump.

3. Water used for testing shall be treated with three different filtration systems to ensure only clean water is used for testing each pump:

a. 25 micron mechanical filter – removes solid parts from water

b. Activated carbon filter – keeps water clear and eliminates odor

c. Ultraviolet light system – kills all bacteria growth

B. The pump manufacturer shall be capable of providing optional performance testing prior to shipment, which shall include the following options: (Select one)

1. 5-Point Verified Performance Test

2. Witnessed Verified Performance Test

2.4 WARRANTY

The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.