SECTION 33 61 00

HYDRONIC ENERGY DISTRIBUTION SYSTEM - VARIABLE PRIMARY AND DISTRIBUTED VARIABLE SECONDARY

Centralized vs Distributed Pump Systems:
Traditional Centralized System: Data from system sensors and pumps are fed back to a central BAS or BMS system. Instructions from theses centralized systems are then sent to the pumps or the VFDs that control the pumps.

Distributed Pump Systems do not require a centralized control system. The VFDs, control hardware, and software are part of each distributed pump. The only wiring required is for power. The pumps can receive data from sensors directly and communicate and coordinate with other pumps via bluetooth technology, cellular connections or WIFI. Distributed pumps can be programmed to work independently, or together in tandem, and further controlled via an app on a smart tablet, phone, or PC.

Contact your Grundfos representative for more information.
https://www.grundfos.com/

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. Furnish and install as shown on plans and in accordance with applicable codes and regulations, a complete pre-fabricated Packaged Pumping System.
      a. Variable speed packaged primary pumping system.
      b. De-coupler system.
      c. Distribution pumping system.
      d. Distributed pumps.
      e. Distributed pumping sequence of operation and integration.
      f. Pump system testing.

1.3 DEFINITIONS

A. The following are abbreviations used in this specfication
   1. IOMs: Internet Only Manuals.
   2. AHU: Air Handling Unit.
   3. AI: Analog Input.
   4. AO: Analog Output.
   5. BAS: Building Automation System.
   6. BMS: Building Management System.
   7. Control MPC DPS: Control Multi Pump Controller Distributed Pump System.
   8. DDC: Direct Dedicated Control.

9. DI: Digital Input.
10. DO: Digital Output.
11. PI: Proportional Integral.
12. PID: Proportional Integral Derivative.
13. SOP: Sequence Of Operation.
14. OA: Outdoor Air.

1.4 REFERENCE STANDARDS

A. The work in this section is subject to the requirements of applicable portions of the following standards:
1. Hydraulic Institute
2. American National Standards Institute (ANSI).
3. American Society for Testing and Materials (ASTM).
4. Institute of Electrical and Electronics Engineers (IEEE).
5. National Electrical Manufacturers Association (NEMA).
6. National Electrical Code (NEC).
7. International Standards Organization (ISO).
8. Underwriters Laboratories, Inc. (UL).

1.5 SUBMITTALS AND IOMs

A. Submit according to provisions provided in Section 01 30 00.

B. Product Data: For each type of product indicated. Include operating characteristics, piping, and wiring diagrams.

C. System Scope Description. Hydronic Energy Distribution indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional structural engineer responsible for their preparation.

D. Shop Drawings:
1. Packaged system dimension and general arrangement drawing.
2. Piping schematic showing all pipe sizes, components, specialties, and instrumentation.
3. Pump material and construction drawing.
4. Pump curve showing design point.
5. Electrical power and control wiring diagrams.
6. Catalog information of all components.

E. Operation and Maintenance Manuals:
1. System scope description.
2. System operation instructions.
3. Packaged system dimension and general arrangement drawing.
4. Piping schematic of packaged system components and specialties.
5. Control panel drawing with list of operator interfaces.
6. Electrical power and control wiring diagrams.
7. Bill of material.
8. Pump and component operation and maintenance instructions.
9. Special electrical component operation instructions.

F. Certificates:
1. Compliance with building codes and regulatory requirements.
2. Performance to the designed water heights and patterns, to the designed water heights and patterns, and to the designed lighting effects.

G. Prior to System Startup:
1. Electronic copy of approved submittals and Installation,
2. Operation and Maintenance Manuals assembled in a neat orderly manner.

1.6 QUALITY ASSURANCE

A. Manufacturer: 15 years' experience in design and construction of packaged pumping systems and 50 years in active design and production of centrifugal pumps.
1. Pumping systems assemblers not actively engaged in the design and construction of centrifugal pumps is not considered a pump manufacturer.
2. Manufacturer is to be responsible for interface and successful operation of all project system components supplied by the pumping system manufacturer.
3. Packaged Pump System Construction Facility: Must be certified to one of the following.
a. ISO 9001 Revision 2008 certified facility.
b. ISO 14001 Revision 2015 certified facility.
c. OSAS 18001 Revision 2007 certified facility.
4. Manufacturer Support:
a. Manufacturer to provide [**commissioning,**] [**start-up,**] [**and**] [**training services**] through factory-provided personnel or a factory authorized representative.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code – Steel

C. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. Packaged Primary Pump System:
1. Certified and Listed by UL (Category QCZJ – Packaged Pumping Systems)
2. Certified and Listed by ETL UL reference (778)

E. Source Limitations: Entire pump system including pumps and pump logic controller, is to be designed, built, and tested by the same single manufacturer.

1.7 DELIVERY STORAGE AND HANDLING

A. Entire packaged pump system is to be factory assembled.
1. Disassembly for Shipment and Handling may require disassembly in sub-assembly form to allow equipment access to final location at jobsite
2. Reassembly of the equipment at the jobsite is the responsibility of the installer. These sub-assemblies will be authorized by the engineer and coordinated between the installer and the packaged pump system manufacturer.

1.8 WARRANTY

A. Warranty Period: Non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering products or systems that may be incorporated into the Work include:"
   1. Grundfos
   2. [_____]

B. Substitutions Request: Considered in accordance with provisions of Section 01 60 00 and the following.
   1. Pre-Approved Alternate Manufacturers: Manufacturers wishing to bid, must submit the following in writing to the owner, or Engineer of Record for approval, 10 days prior to bid date.
      a. Proof of manufacturing similar products for a minimum of 10 years.
      b. Deviations to this specification.
      c. Component data sheets.
      d. Sequence of operation.

2.2 VARIABLE SPEED PACKAGED PRIMARY PUMP SYSTEM

A. Variable Speed Packaged Primary Pump System: Includes all products, sequence of operation and system construction relating to primary pumps commonly located in the mechanical room near the chiller or boiler before the de-coupler.
   1. Control Logic: Protects component minimum flow thresholds and balances flow in hydronic HVAC systems between a primary loop and secondary loop based on temperature control.
      a. Logic analyzes actual flow measurements or differential pressure sensors.
   2. Performance at Operation Conditions:
      a. Capable of delivering at design conditions, [_____] US gpm at total dynamic head (TDH) of [____] feet.
      b. Pumped Liquid: Water at [____] degrees F.
      c. Achieve total flow capacity using [____] duty pumps.

Editor's Note: Delete additional standby pump if not required.

         1) Additional [____] standby pump.
   3. Skid Base and Structure:
      a. Will support system weight at loading and unloading.
      b. Installed per IOM Instructions: Support system weight during operation without exceeding deflection limits.
   4. Suction and Discharge of Each Pump: Fitted with isolation valves, allowing pump servicing while system is in operation.
      a. Pump Discharge for Each Pump:
         1) Fitted with Dual Disc Check valve.
         2) Fitted with Silent Check valve.

B. Components:
   1. Skid Base Structure:
      a. Materials: Constructed of fabricated carbon steel.
      b. Structural Steel, Bars, and Plates: ASTM A36 grade meeting ASTM A6 requirements.
      c. Structural Channels, I-Beams, and Square Tubing: Provide MTR reports upon request.
      d. Design Requirements:
         1) Load Bearing Beams: Contained within and welded to steel I-beams or structural channel exterior.
         2) Appropriate Space and Clearance: For access, operation, and maintenance of supplied equipment.
         3) Skid Working Surface: Plate steel. Thickness: 3/16 inch minimum
            a) Cover entire base and stitch welded to structural members providing a secure mounting surface for components.

b) Internal Support Members: 2 inches in width and welded underneath to provide additional stiffness and mounting support to heavy equipment.
c) Equipment Mounted to Working Surface: Leveled, shimmed, then grouted around the edges as required by others.
d) Additional structural seismic inserts may be required. <eet code requirements for authorities having jurisdiction.

4) Equipment for Outdoor Installation: Must have complete seal welded plate, equipment, and pipe supports in exposed areas of the skid base.
5) Lifting Provisions: Incorporated into skid design.
a) Lifting Lugs: Plate style or Phoenix style installed on exterior running members of skid structure.

e. Manufacturing Requirements:
1) Structural Welds: Performed by AWS D1.1 certified welders.
2) Welds: To be of high quality, ground clean, and free of slag, pinholes, and undercut.
3) Welded Structural Members, Brackets, Pipe and Equipment supports, and Racks: Completely seal welded.
a) Plates: May be stitch welded.
4) Skid Grounding Lugs: Two drilled and tapped grounding lugs located at opposite corners of skid and seal welded to exterior structural member web.
5) Skid Diagonal Measurement: Must fall within 1/4 inch of calculated value using the square root of the sum of the squares of the measured length and measured width.
6) Welds at Four Corner Joints: Liquid penetrant tested in accordance with ASTM E1417-95a.
7) Lifting Lugs: Liquid penetrant tested in accordance with ASTM E1417-95a.

2. Primary Pumps System:

Editor's Note: The primary packaged pump system will be determined and added during the system design. Design specifics will be based on input for the Contractor and design parameters supplied by the Engineer of Record for the Project. Verification and testing of the primary pump system may witnessed by the Contractor or Engineer of Record for additional fee. Refer to Primary Pump Packaged System Specification, if not specified here, for more information.

3. Piping and Fittings:
a. Piping System:
1) Package Piping: Fabricated welded steel headers.
2) Fittings: Comply with ASME Code B.31.1 and B.31.3.
3) System Piping: Sized for maximum velocity of 10 feet per second.
a) Branch Piping to Pumps: Sized for design capacity of pump.
b) Base Mounted Supports: For the suction header and the discharge header.
c) Piping Supports: To be independent of pump connections.
d) Supports welded directly to pipe is not acceptable.

Editor's Note: Delete insulation paragraph if not required.

e) Arrange supports to permit field installation by contractor of [___] inch thick pipe insulation.
f) Drain Plugs: In any low piping that may collect water.
g) Suction and Discharge Connections: ANSI Class 150 or 250 flange, grooved end, or national pipe thread (NPT) as shown on the Drawings.

b. Piping Material: [ASTM A53 pipe Type E, electric resistance welded. Minimum Wall Thickness: Schedule 40 for pipe 10-inch and less and standard schedule for pipe 12 inch and above.] [ASTM A53 pipe Type S.] [ASTM A106 seamless pipes.]
c. Fittings and Appurtenances: Fittings to be rated for pressure and loadings equal to pipe.

1) Steel Fittings and Appurtenances: Conform to requirements of ASTM A234, ASTM A105, or ANSI B16.11 and ASME B16.5 including bolts, nuts, and gaskets.
2) Malleable Iron Threaded Fittings and Appurtenances: Conform to requirements of ASTM A47 or ASTM A197, ANSI B16.3.
3) Fittings for Grooved End Piping Systems: Full flow cast fittings, steel fittings, or segmentally welded fittings with grooves or shoulders designed to accept grooved end couplings.
   a) Cast Fittings: Ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47.
   b) Standard Steel Fittings Including Large Size Elbows: Forged steel conforming to ASTM A106.
   c) Standard Segmentally Welded Fittings: Schedule 40 carbon steel pipe.

4. Valves:
   a. Butterfly Valves: Furnished on suction and discharge of pumps.
      1) Ductile iron lug body, EPDM seat, 304 stainless steel disc, stainless steel shaft and PTFE bushings.
      2) Valves 6 inches and Smaller: Provide with lever operators
      3) Valves 8 inches and Larger: Provide with hand-wheel and gear operator.
      4) Piping Isolation Valves: Provided as shown on system P&ID.*

Editor's Note: Delete chain operators if not required.

      5) Chain Operators: Provided for valves over 6 ft from working surface.
   b. Wafer Style Check Valves: Furnished on the discharge of each pump.
      1) Cast iron body with pressure rating equal to pump shut-off head plus maximum suction pressure.
      2) Valve Discs: 304 stainless steel with stainless steel spring.
   c. Isolation Valves: Furnished on the suction and discharge of each pump.
      1) Valves 2 inches and Smaller: Full port ball valves. Nickel plated brass.
      2) Valves 3 inches and Larger: Butterfly valve. Full lug style.
         a) Disk: stainless steel.
         b) Seat: EPDM
         c) Body: Cast iron, coated internally and externally with fusion-bonded epoxy.
5. Suction Diffusers with Integral Strainer: Furnished on suction of each pump.
   a. Body: Cast iron.
   b. Strainer: 304 stainless steel. Full size.
   c. Mounted Blow-Down Valve: Piped to drain by contractor.
6. Y Strainers: Furnished on suction of each pump.
   a. Body: Cast iron.
   b. Strainer: 304 stainless steel. Full size.
   c. Mounted Blow-Down Valve: Piped to drain by contractor.
7. Tangential Air Separators: Provided for the packaged system.
   a. Construct in accordance with ASME boiler and pressure vessel code and stamped for 125 psig design pressure or higher.
   b. Welded steel tank.
   c. Tangential Inlet and Outlet Connections: [____] inch.
   d. Supplied with automatic air release valve with isolation valve.
   e. If Air Separator Includes a Strainer or Screens: Install with butterfly valves, access plates, and blow down valves to facilitate screen cleaning.
8. Expansion Tank: [____] gallons.
   a. Pre-charged carbon steel pressurized tank with replaceable heavy-duty rubber bladder. Constructed in accordance with Section VIII of the ASME boiler and pressure vessel code and stamped 125 PSIG design pressure.
   b. Expansion Tank System Run-Out Piping: Include a minimum 18 inch deep anti-thermal syphon loop, isolation valve and a drain valve.
9. Chemical Shot Feeder: [____] gallons.

a. Piped across the system and include shut-off valves and drain connection with valve.

10. Make-up Water System: [____] inches.
    a. Includes a pressure reducing valve set at [____] psig, double check valve type backflow preventer when required, shut-off valves, Y-strainer, pressure gauge, and manual bypass.
11. Factory Choice Material:
    a. Pressure Sensor Transducers: Factory installed on discharge manifold or field installed as specified on the Drawings.
        1) Systems with Positive Inlet Gauge Pressure: A factory installed pressure transducer on suction manifold for water shortage protection.
        2) Material: 316 stainless steel.
        3) Accuracy: +/- 1.0% full scale with hysteresis and repeatability no greater than 0.1% full scale.
        4) Output Signal: 4 to 20 mA with supply voltage range of 9 to 32 VDC.

Editor's Note: Delete Temperature Sensor Transducers not required.

    b. Temperature Sensor Transducers: Factory installed, or field installed as specified on the Drawings.
        1) Temperature Transducers: 316 stainless steel.
        2) Accuracy: +/- 1.0% full scale.
        3) Output Signal: 4 to 20 mA. Supply voltage range of 10 to 30 VDC, measuring range of any combination between -50 to 200 degrees C. Media temperature of -50 to 200 degrees C. Sensor Pockets: Used for temperature sensors.
    c. Temperature Sensor Transducers with Local Readout of Temperatures: Factory installed, or field installed as specified on the Drawings.
        1) Sensors will have local readout and wired back to controls for monitoring. Temperature Transducers: 316 stainless steel and be PT100 RTD's; thermocouple Type J, Type K, and Type T.
        2) Temperature Ranges:
            a) RTDs: -321 to 842 degrees F
            b) Thermocouples: -321 to 2192 degrees F.
        3) RTD must be paired with device to display current temperature reading and output 4 to 20 mA to controls with a supply voltage range of 9 to 32 VDC.
        4) Display: Alternates up to four selected items and display up to five digits in engineering units (°F, °C, °R, K, Ω, and millivolts).
        5) Display Settings: Configured at factory according to transmitter configuration (standard or custom).
        6) Standard Sensor: Rosemount 3144P with 214C RTD.
    d. Stability:
        1) RTDs: +/- 0.1% of reading or 0.1 degree C, whichever is greater, for 24 months.
        2) Thermocouples: +/- 0.1% of reading or 0.1 degree C, whichever is greater, for 12 months.
    e. Bourdon Tube Pressure Gauge: 4-1/2-inch diameter, on suction and discharge manifolds.
        1) Gauge to be liquid filled. Accuracy: 2/1/2 %.
        2) Capable of pressure 30% above its maximum span without requiring recalibration.
        3) Include isolation shut-off valves to permit isolation and replacement of component.
    f. Thermometer: Factory installed on manifold or field installed as specified on the Drawings.
        1) Accuracy: +/- 1 Scale Division.
    g. Ball Valves 2 inches and Below: Bronze, threaded, 2-Piece, full port, with 2-point mounting, 600 CWP and /or Threaded 2-piece.

Editor's Note: Paragraph below is optional. Delete of not required.

1) Bronze Cap and Chain Hose connection.

12. Power and Control Panels:
    a. UL Type 12 enclosure properly sized to contain the required components.
    b. Construction: 14 GA Powder coated ANSI-61 with sub-panel.
        1) Racks: Steel, designed for mounting power and control panels or other rack-mountable electronic equipment.
    c. Free Standing Panels: Bolted to skid base.
    d. Labels: Voltage identifications and comprehensive warnings.
    e. To Maintain Environmental Rating of Specified Equipment and Enclosure: Install in openings only certified or recognized devices with same integrity as enclosure, in compliance with installation instructions of the device.
13. Variable Frequency Drives:
    a. Convert incoming fixed frequency single-phase or three-phase AC power into a variable frequency and voltage for controlling the speed of Single Phase or three-phase AC induction motors.
        1) Six-pulse input design, and input voltage rectifier to employ a full wave diode bridge.
            a) Not Acceptable: VFDs utilizing controlled SCR rectifiers.
        2) Output Waveform: Closely approximate a sine wave. A PWM output utilizing current IGBT inverter technology and voltage vector control of the output PWM waveform.
    b. Full-wave diode bridge rectifier. Maintain a displacement power factor of near unity regardless of speed and load.
    c. Produced Output Waveform: Capable of handling maximum motor cable distances of up to 1,000 ft. unshielded without tripping or derating.
    d. Utilize an output voltage-vector switching algorithm, or equivalent, in both variable and constant torque modes.
        1) Not Acceptable: VFD's that utilize Sine-Coded PWM or Look-up tables.
    e. Automatically boost power factor at lower speeds.
    f. Provide full rated output current continuously at 110% of rated current for 60 seconds.
    g. Empty Pipe Fill Mode: To fill an empty pipe in a short period of time, then revert to PID controller for stable operation.
    h. Switching off Input Power to VFD: To be possible without interlocks or damage to VFD at a minimum interval of 2 minutes.
    i. Switching off Power on Output Side Between VFD and Motor: Possible with no limitation or damage to VFD and require no additional interlocks.
    j. Temperature Controlled Cooling Fans: For quiet operation, minimized internal losses, and increased fan life.
    k. Full torque to motor given input voltage fluctuations of up to +10% to -15% of rated input voltage.
    l. Internal DC Link Reactors: Minimizes power line harmonics and provides near unity power factor.
        1) VFDs Without DC Link Reactors: Provide 5% impedance line side reactor.
    m. Protective Features:
        1) Input surge protection utilizing MOVs, spark gaps, and Zener diodes to withstand surges of 2.3 times line voltage for 1.3 msec.
        2) Circuitry to detect phase imbalance and phase loss on input side of VFD.
        3) Current sensors on all three-output phases to detect and report phase loss to motor. VFD will identify which output phase is low or lost.
        4) Auto-derate of output voltage and frequency to motor in presence of sustained ambient temperatures higher than normal operating range, so as not to trip on an inverter temperature fault.
            a) This feature to be user-selectable. A warning will be exported during the event. Function will reduce switching frequency before reducing motor speed.

5) Auto-derate of output frequency by limiting output current before allowing VFD to trip on overload. Speed can be reduced, but not stopped.
6) Integral RFI Filter: VFD enclosures to be metal minimizing RFI and providing immunity.

n. Interface Features:
1) Alphanumeric Backlit Display Keypad: May be remotely mounted using standard 9-pin cable.
a) VFD may be operated with keypad disconnected or removed entirely.
b) Keypad may be disconnected during normal operation without stopping the motor or disconnecting power to VFD.
2) Display of faults in plain text,
a) Not Acceptable: VFDs, which display only fault codes.
3) VFDs to be the same series and utilize common control cards and LCP (keypad and display unit) throughout the rating range.
a) Control Cards and Keypads: Interchangeable through entire range of drives on project.
4) VFD Keypad: Capable of storing drive parameter values in non-volatile RAM uploaded from the VFD. Capable of downloading stored values to VFD to facilitate programming of multiple drives in similar applications, or as a means of backing up the programmed parameters.
5) Red FAULT Lights, a Yellow WARNING Lights, and a Green POWER-ON Lights: Visible on keypad and on VFD when keypad is removed.
6) Start Guide Menu: Factory preset typical parameters provided on VFD to facilitate commissioning.
7) Full galvanic isolation with suitable potential separation from power sources (control, signal, and power circuitry within the drive). Ensure compliance with PELV requirements and protect PLC's and other connected equipment from power surges and spikes.
8) Inputs and Outputs: To be optically isolated.
a) Isolation boards between VFD and external control devices are not to be required.
9) Three Programmable Digital Inputs: For interfacing with systems external control and safety interlock circuitry. An additional digital input is preprogrammed for start and stop.
10) Two Analog Signal Inputs: One dedicated for sensor input and one for external set point input.
11) One Programmable Analog Output: Provided for indication of a drive status.
12) Two user programmable relays with selectable functions.
a) Two form 'C' 230VAC/2A rated dry contact relay outputs.
13) Must Store in Memory: The last 5 faults with time stamp and recorded data.
14) A Standard RS-485 Serial Communications Port: For communication to multi-pump controller. The bus communication protocol for the VFD to be the same as the controller protocol.

o. VFD Service Conditions:
1) Ambient Temperature Operating Range: 14 to 113 degrees F.
2) Relative Humidity, Non-Condensing: 0 to 95%.
3) Elevation: To 3,300 feet without derating.
4) Rated for line voltage of [**525 to 690 VAC**] [**380 to 480VAC**] [**200 to 240VAC**]; with +10% to -15% variations. Line Frequency Variation of ± 2% is acceptable.
5) No side clearance is to be required for cooling of units.

14. Pump System Controller: Standard product developed and supported by pump manufacturer.
a. Microprocessor based, capable of software changes and updates via personal computer.
b. User Interface: Color display. Screen Size: 3-1/2 x 4-5/8 inch minimum for viewing system status parameters and field programming.

1) Back light with contrast adjustment.
2) Password protection of system settings.

c. Provide internal galvanic isolation to digital and analog inputs, and fieldbus connections.
d. Battery Connection: To maintain power on controller during periods of supply power loss.
e. Built-in data logging. Graphically display logged values with ability to export data.
   1) Number of Samples: 3600 per logged value with the following parameters available for logging:
      a) Estimated flow-rate.
      b) Speed of pumps.
      c) Inlet pressure.
      d) Process Value. Usually discharge pressure of differential pressure depending on application.
      e) Power consumption.
      f) Controlling parameter; process value.
f. Default Display of Status Readings from a Single Display on Controller:
   1) Current value of the control parameter, (typically discharge pressure).
   2) Most recent existing alarm (if any).
   3) System status with current operating mode.
   4) Status of each pump with current operating mode and rotational speed as a percentage.
   5) Estimated flow-rate, (not requiring flow meter connection).
g. Controller to have the following hardware inputs and outputs:
   1) Three analog inputs (4-20mA or 0-10VDC).
   2) Three digital inputs.
   3) Two digital outputs.
   4) Ethernet connection.
   5) Field Service connection to PC for advanced programming and data logging.
h. Pump system programming (field adjustable) to include the following:
   1) Water shortage protection (analog or digital).
   2) Sensor Settings (Suction, Discharge, Differential Pressure analog supply/range).
   3) PI Controller (Proportional gain and Integral time) settings.
   4) High system pressure indication and shut-down.
   5) Low system pressure indication and shut-down.
   6) Low suction pressure/level shutdown (via digital contact).
   7) Low suction pressure/level warning (via analog signal).
   8) Low suction pressure/level shutdown (via analog signal).
   9) Flow meter settings (if used, analog signal).
i. Capable to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).
j. Advanced Water Shortage Protection: Two indication levels when analog sensors, level, or pressure, are used for water shortage protection.
   1) One Level: For warning indication only (indication that water level or pressure is getting lower than expected levels)
   2) One Level: For complete system shut-down (water or level is so low that pump damage can occur).
   3) System Restart After Shut-Down: Manual or automatic and be user selectable.
k. System Pressure Set-Point: Capable of being automatically adjusted by an external set-point influence.
   1) Set-Point Influence Function: Enables user to adjust control parameter (typically pressure) by measuring an additional parameter.

a) Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates.

l. Capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) and remote system on/off (digital) signal.

m. Capable of adjusting ramp time of a change in set point on both an increase and decrease change in set point.

n. Store up to 24 warning and alarms in memory. Record time, date, and duration of each alarm. A potential-free relay for alarm notification to the building management system.
   1) Display the Following Alarm Conditions:
      a) High System Pressure.
      b) Low system pressure.
      c) Low suction pressure (warning and alarm).
      d) Individual pump failure.
      e) VFD trip/failure.
      f) Loss of sensor signal (4-20 mA).
      g) Loss of remote set-point signal (4-20mA).

o. Mounted in UL Type 12 rated enclosure.
   1) Entire Control Panel: UL 508A listed assembly. Includes a main disconnect, circuit breakers, or fuses for pumps, control circuits, and control relays for alarm functions.
   2) Control Panel Options
      a) Pump Run Lights
      b) System Fault Light
      c) Audible Alarm (80 db[**A**])
      d) Surge Arrestor
      e) Emergency/Normal Operation Switches
      f) Service Disconnect Switches
      g) Qty (9) Configurable Digital Outputs available for monitoring

p. Capable of receiving a redundant sensor input to function as a backup to primary sensor (typically discharge pressure).

q. 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 to 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. Capable of changing the number of pumps available to operate or can limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.

s. Capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

t. Capable of displaying instantaneous specific energy use (kW/gpm), (optional flow meter must be connected).

u. The actual pump performance curves (5^{th} order polynomial) shall be loaded (software) into the pump system controller. Pump curve data to be used for the following:
   1) Display and data logging of calculated flow rate (not requiring flow measurement).
   2) Proportional pressure control.
   3) Pump outside of duty range protection.
   4) Pump cascade control based on pump efficiency.

v. Capable of displaying an estimated flow-rate on the default status screen.

w. Proportional Pressure Control: To compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates by using actual flow rate or calculated flow rate. Proportional pressure

control that uses pump speed or power consumption only shall not be considered equal to proportional pressure control that uses actual or calculated flow rate.

x. Ability to communicate common field-bus protocols, (BACnet, Modbus, Profibus, and LON), via optional communication expansion card installed inside controller.

y. Ethernet connection with a built-in server allowing for connection to a network with read/write access to controller via web browser and internet.

z. Programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

aa. Capable of balancing the flow between the primary loop and the secondary distributed loop via analog input at the de-coupler from temperature sensors and flow or differential pressure sensors.

bb. Able to run two separate PI loops simultaneously.

cc. Minimum Flow Protection:

1) When using analog sensors for flow or differential pressure, utilize a threshold and offset level.

a) Threshold Level: For warning and control adjustment.

b) Offset Level: For adding a safety margin to the threshold.

2) Control logic adjusts pump speed to stay above minimum flow threshold plus offset.

dd. Capable of regulating pump speed and flow based on differential temperature measured between a primary loop and a secondary loop.

ee. PIN code for user protection

ff. Multi-lingual where a user is be able to quickly change user language (Spanish, English, Chinese, French)

C. Sequence of Operations:

1. Temperature Control with Minimum Flow Protection. HVAC hydronic Applications.

2. System Controller: Capable of controlling flow depending on temperature differential between supply and return around the de-coupler while keeping minimum flow at chillers.

3. Standard Temperature Control Balancing Primary and Secondary Loop:

a. System Controller:

1) Works continuously to keep differential temperature on the primary loop equal to the differential temperature measured on the secondary loop on each side of the de-coupler pipe.

a) When loops are equal in temperature, there is no de-coupler flow and the primary loop and secondary loop are in balance.

2) Control is based on its PI control loop and accelerate or de-accelerate pumps if either the primary loop differential temperature is higher than secondary loop or if secondary loop is higher than primary loop.

3) Flow Optimization: Happens between primary and secondary loop while the controller at any time ensures a minimum flow at a component is kept. In a scenario where the minimum flow is activated the controller will speed up the pumps regardless of temperature measurements.

4. Standard Cascade Control (Pumping Efficiency Based):

a. Pump System Controller: Adjusts pump speed as necessary to maintain system set-point pressure as flow demand increases.

b. Utilizing the pump curve information (5th order polynomial), pump system controller will stage on additional pumps when pump hydraulic efficiency will be higher with additional pumps in operation.

1) Exception: When the flow and head are outside the operating pumps allowable operating range the controller will switch on an additional pump thus distributing flow and allowing all pumps to operate in allowable operating range.

c. When system pressure is equal to system set-point, all pumps in operation will reach equal operating speeds.

d. Field adjustable proportional gain and Integral time (PI) settings for system optimization.

5. Optional Cascade Control (Pump Start Speed Based):
   a. As flow demand increases the pump speed will be increased to maintain the system set-point pressure.
   b. When operating pumps reach 96% of full speed (adjustable), an additional pump is started and will increase speed until the system set-point is achieved.
   c. When system pressure is equal to the system set-point all pumps in operation are to reach equal operating speeds. The pump system controller has field adjustable Proportional Gain and Integral time (PI) settings for system optimization.
6. System Controller: Capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors, or temperature measuring devices.
7. All System Pumps: Will alternate automatically based on demand, time, and fault.
   a. For Continuous Flow Demand: System controller is to have the capability to alternate the pumps [**every 24 hours**] [**every 48 hours**] [**or**] [**once per week**].
      1) The interval and actual time of pump change-over is to be field adjustable.

D. Finishing:
1. Steel Components: Cleaned, degreased and painted with a rust preventive primer.
2. Complete Packaged Pump Systems: Factory painted with two-part polyurethane epoxy and allowed to dry before shipping.
   a. Color: RAL 9005, Low gloss black.

E. Factory Testing: Prior to shipping from Manufacturer's facility.
1. Test Result Documents and Inspection Result Documents:
   a. To be made available upon customer request.
2. Factory Hydrostatic Test: At end of production cycle per ASME B31.1
   a. Piping System: Fill with water and pressurize to 1.5 times the design psi or minimum 100 psi. Maintain pressure for 10 minutes with no leakage
3. Inspections:
   a. Factory Electrical Termination Verification: Verify all points are terminated.
   b. Functionality Test and Inspection: To electrical components; lights, receptacles, exhaust fans, A/C unit, and heater.

Editor's Note: The following two items or optional. Delete if not required.

4. Megger Test: If requested by the customer.
5. System Factory Performance Test: On complete unit. Confirm the system duty point prior to shipment.

2.3 DE-COUPLER SYSTEM

A. De-Coupler System: Includes products and construction items for the de-coupler which separates the primary side from the secondary distributed side of the HVAC hydronic system . Allows primary pumping system bypass flow to maintain minimum required flows.
1. Four Single Temperature Sensors, or Two Differential Temperature Sensors: Located on the supply and distribution side of the de-coupler.
   a. Sensor Location: 5 x Pipe Diameter distance from the de-coupler.
   b. Sensor Type: Analog with a 4 to 20 mA interface connected to the system controller. Sensor accuracy shall be +/- 0.5% full scale. The sensors shall be suitable for HVAC applications.
2. Differential Pressure Sensors or Flow Meters: Install Up to 5, across the component where minimum flow protection is required.
   a. Accuracy: +/- 2% of full scale. Suitable for HVAC applications.
   b. Analog with a 4 to 20 mA interface connected to the system controller.

Editor's Note: Flow meters are optional and only to be used if already present in the application for the component where minimum flow protection is required. Delete paragraph if not required.

c. Flow Meters: Analog with a 4 to 20 mA interface connected to the system controller.

2.4 DISTRIBUTION PUMPING SYSTEM

A. Distribution Pumping System: All products, sequence of operation. and system of construction for the secondary side of the HVAC hydronic system where hydronic energy transfer occurs on the load side of the system.
1. Pump Isolation Valves: Furnished on suction and discharge of each pump.
   a. Valves 2 inches and Smaller: Full port ball valves. Nickel plated brass.
   b. Valves 3 inches and Larger: Butterfly valve. Full lug style.
      1) Disk: stainless steel.
      2) Seat: EPDM
      3) Body: Cast iron, coated internally and externally with fusion-bonded epoxy.
2. Check Valve: Spring-loaded, non-slam type. Located on the discharge of each pump.
   a. Valve Type: Wafer style fitted between two flanges.
   b. Head Loss Through Check Valve: 5 psi or less at pump design capacity.
      1) Valves 1-1/2 inches or Smaller: POM composite body and poppet, stainless steel spring with EPDM or NBR seats.
      2) Valves 2 inches and Larger: Stainless steel or epoxy coated iron (fusion bonded) body with an EPDM or NBR resilient seat, and stainless steel spring.
         a) Disk: Stainless steel or leadless bronze.

2.5 DISTRIBUTED PUMPS

A. In-Line Variable Speed Wet Rotor Circulator Pumps:
1. Basis of Design: Magna 3 as manufactured by Grundfos.
   a. Not Acceptable: Oil lubricated pumps and shaft coupled pumps.
2. Standard product of a single pump manufacturer. Pump, motor, and variable speed drive. An integral product designed and built by the same manufacturer.
3. Enclosure: Marked "Enclosure Type 2."
4. Certification and Listing: By a Nationally Recognized Test Laboratory (NRTL) for U.S. and Canada to comply with the following:
   a. UL 778.
   b. UL 60730-1A.
   c. CAN/CSA No. 108.
5. Energy Efficiency Index (EEI): No greater than 0.20.
   a. The EEI to be labeled on pump nameplate.
6. Ratings:
   a. Maximum Pressure: 175 psig.
   b. Minimum Media Temperature: 14 degrees F.
   c. Maximum Media Temperature: 230 degrees F.
   d. Maximum Continuous Media Temperature: 203 degrees F.
   e. Maximum Sound Pressure Level: 43 dB(A).
7. Voltage: [1x115V +/-10%] [1x208-230V +/-10%]
8. Maximum Energy Efficiency Index: 0.20.
9. Pump Construction:
   a. Pump housing: Cast Iron: EN-JGL-250 with Cataphorese surface treatment.
   b. Impellers: Composite PES 30% GF.
   c. Rotor Can: PPS reinforced with Carbon Fiber(Fortran MT9141L PPS-GF40).
   d. Rotor Cladding: 316 Stainless Steel.
   e. Stator Housing: Aluminum.
   f. Shaft: 316L Stainless Steel.
   g. Thrust Bearing: Axial: Carbon Graphite, Radial: ceramic Alumina Hilox 961.

h. O-Rings: EPDM.
i. Bearing Plate: 304 Stainless Steel.
j. Neck Ring: 304 Stainless Steel.
k. Control Box: Polycarbonate.

10. PM Motor: 4-pole permanent-magnet tested with pump as one unit by the same manufacturer.
    a. Not Acceptable: Conventional asynchronous squirrel-cage motors.
    b. Integrated Variable Speed Drive (VSD).
    c. Motor and VSD to be built and tested as one unit by same manufacturer.
    d. Stator Housing: Pressure die cast aluminum.
    e. Motor Cooling: By the pumped fluid. Motor to be self-ventilating.
    f. Power Electronics: Cooled to ambient air.
    g. Minimum Motor Insulation: Class F.
    h. Integrated VFD Control: Minimizes energy consumption by utilizing an energy optimization algorithm, then reduces the factory-set setpoint and adjusts to system characteristics. Accomplished without need of external sensors or input.
11. Operating Modes: Pump to have the following control mode and operating modes:
    a. AUTOADAPT: During operation, the pump automatically reduces the factory-set setpoint and adjusts it to the actual system characteristic.
        1) Manual setting of setpoint is not possible.
    b. FLOWLIMIT: The user may select a maximum flow that the pump will not exceed to eliminate the need for additional throttling valves.
        1) Pump will operate per selected control mode but will limit speed to not exceed the user specified flow limit.
    c. FLOWADAPT: Pump operates in AUTOADAPT mode with FLOWLIMIT enabled.
    d. Proportional Pressure: Delivered head to be reduced from a manual setpoint linearly in accordance with decrease in system flow demand.
    e. Constant Pressure: Manual setting. Constant head is maintained, irrespective of flow up to the maximum pump speed.
    f. Constant Curve: Pump runs as an uncontrolled pump by means of a set of pump curves. The pump curve adjustable between maximum and minimum from the control panel or through a wireless remote control.
    g. Constant Temperature: Pump adjusts speed to maintain a constant media temperature in the flow pipe to which the pump is installed.
    h. Constant Differential Temperature: Pump adjusts speed to maintain a constant temperature drop between the flow pipe to which the pump is installed, and user installed temperature sensor in the volute of the pump.
    i. Alternating Operation: Two single head pumps or two heads of a dual head pump communicate wirelessly to one another.
        1) In Alternating Operation: Only one pump operates at a time.
        2) Operation alternates based on time or energy ensuring even run time of both pumps.
        3) If a pump stops due to a fault the alternate pump takes over automatically.
    j. Back-Up Operation: Two single head pumps or two heads of a dual head pump communicate wirelessly to one another.
        1) In Back-Up Operation: One duty pump operates continuously.
        2) If duty pump stops due to a fault, the back-up pump takes over automatically.
    k. Cascade Operation: Two single head pumps or two heads of a dual head pump communicate wirelessly to one another.
        1) Two pumps operate together in constant pressure control.
        2) Pump Controller: Determines when to operate a single pump or both pumps to meet demands. While both pumps operate, they will run at the same speed.
12. Interface and Communication:
    a. Pump to have an Integrated Operator Interface:
        1) Minimum 2.4 inch (measured diagonally) color TFT display.
        2) Push Buttons: A quantity of seven for navigation of menu.

a) Must be able to operate 25,000 times.
b) Must be isolated from the main supply by reinforced insulation according to UL 60730.
3) LEDs: Signal pump status for quick indication.

b. Sensor Integrated Directly into Pump Housing: 4 lines; ground, supply, and two signals for differential pressure and media temperature.
1) Sensor Supply: 4.8V DC +/- 2% at 20mA referenced to Ground. Must be able to withstand a permanent short circuit.

c. Pump Module One Analog Input:
1) Configurable for 4 to 20mA or 0-10 VDC input signal for external temperature or pressure sensor, or setpoint influence.
2) Sensor Input: Three wires for ground, supply, and signal.
a) External Analog Supply: Input: 24 VDC +/-10% at 22 mA reference to Ground and able to withstand a permanent short circuit.
b) Connection: Screw terminal capable of wire sizes up to AWG16.

d. Digital Inputs: Galvanically isolated from main supply by reinforced insulation according to UL 60730. Quantity of three inputs.
1) Start and Stop: Pump is enabled when connected to common ground by an external potential free short circuit.
a) An open circuit to this input will disable the pump.
b) Connection: Screw terminal capable of wire sizes up to AWG16.
2) Minimum: Used to force pump to run at minimum load (curve).
a) When connected to common ground by an external potential free short circuit the pump will run at minimum load.
b) Connection: Screw terminal capable of wire sizes up to AWG16.
3) Maximum: Used to force the pump to run at maximum load (curve).
a) When connected to common ground by an external potential free short circuit the pump must run at maximum load.
b) Connection: Screw terminal capable of wire sizes up to AWG16.

e. Pump Module Output Relays: Quantity of two.
1) Configurable for alarm, reading, or operating indication.
2) Each relay must have three screw terminals.
3) Output Relay Contacts Ratings:
a) Maximum: 250 VAC at 2A.
b) Minimum: 5 VDC at 20 mA.
c) Relays must have galvanic isolation from the internal supply by reinforced insulation according to UL 60730.

13. Building Management Systems Integration: Capable of accepting add-on modules for the following BMS:
a. LonWorks.
b. Bacnet IP.
c. MSTP Modbus.
d. Profibus.

14. Wireless Communication Connectivity: Between two pumps modules or between a pump and a mobile device with use of additional hardware.
a. Communication Range: 30 ft without walls or barriers.
b. Two Identical Pumps Capable of Wireless Communication: Able to operate with one another as a two pump system in the following capacities:
1) Duty and standby
2) Alternating Mode: Pumps alternate operation every 24 hours.
3) Cascade Operation: Pumps running simultaneously in constant differential pressure mode.

B. Variable Speed Vertical In-Line Pump:
1. Basis of Design: TPE 3 as manufactured by Grundfos.

2. Standard Product of a single pump manufacturer. Pump, motor, and variable speed drive with internal PI controller. An integral product designed and built by the same manufacturer.
3. Certification and Listing: By a Nationally Recognized Test Laboratory (NRTL) for U.S. and Canada to comply with the following:
    a. UL 778.
    b. UL 60730-1A.
    c. CAN/CSA No. 108.
4. Ratings:
    a. Maximum Pressure: 145 psig.
    b. Minimum Media Temperature: 32 degrees F.
    c. Maximum Media Temperature: 248 degrees F.
    d. Voltage: 3 x 440 to 480 V.
5. Pump Construction:
    a. Pump housing: Cast Iron: EN-JGL-250.
    b. Impellers: Composite PES 30% GF.
    c. Shaft: 316L stainless steel.
    d. Thrust Bearing: Axial: Carbon Graphite. Radial: Ceramic Alumina Hilox 961.
    e. O-Rings: EPDM.
    f. Bearing Plate: 304 stainless steel.
    g. Control Box: Polycarbonate.
    h. Rigid Coupler: Stainless steel.
    i. Seal: Carbon-Ceramic or Silicon Carbide.
    j. Clamp Ring: 304 stainless steel.
6. Motor:
    a. Fan cooled; permanent-magnet synchronous motor tested with pump as one unit by same manufacturer. Efficiency Rating: IE5.
        1) Not Acceptable: Conventional asynchronous squirrel-cage motors.
    b. Integrated Variable Speed Drive design consisting of a motor and a variable frequency drive (VFD) built and tested as one unit by same manufacturer.
        1) Utilize an energy optimization algorithm minimizing energy consumption by reducing the factory-set set point and adjust to system characteristics.
            a) Accomplished without any external sensors or input.
7. Operating Modes: Pump to have the following control and operating modes:
    a. AUTOADAPT: During operation, the pump automatically reduces the factory-set setpoint and adjusts it to the actual system characteristic.
        1) Manual setting of setpoint is not possible.
    b. FLOWLIMIT: The user may select a maximum flow that the pump will not exceed to eliminate the need for additional throttling valves.
        1) Pump will operate per selected control mode but will limit speed to not exceed the user specified flow limit.
    c. FLOWADAPT: Pump operates in AUTOADAPT mode with FLOWLIMIT enabled.
    d. Proportional Pressure: Delivered head to be reduced from a manual setpoint linearly in accordance with decrease in system flow demand.
    e. Constant Pressure: Manual setting. Constant head is maintained, irrespective of flow up to the maximum pump speed.
    f. Constant Curve: Pump runs as an uncontrolled pump by means of a set of pump curves. The pump curve adjustable between maximum and minimum from the control panel or through a wireless remote control.
    g. Constant Temperature: Pump adjusts speed to maintain a constant media temperature in the flow pipe to which the pump is installed.
    h. Constant Differential Temperature: Pump adjusts speed to maintain a constant temperature drop between the flow pipe to which the pump is installed, and user installed temperature sensor in the volute of the pump.
    i. Alternating Operation: Two single head pumps or two heads of a dual head pump communicate wirelessly to one another.
        1) In Alternating Operation: Only one pump operates at a time.

2) Operation alternates based on time or energy ensuring even run time of both pumps.
3) If a pump stops due to a fault the alternate pump takes over automatically.

j. Back-Up Operation: Two single head pumps or two heads of a dual head pump communicate wirelessly to one another.
1) In Back-Up Operation: One duty pump operates continuously.
2) If duty pump stops due to a fault, the back-up pump takes over automatically.

k. Cascade Operation: Two single head pumps or two heads of a dual head pump communicate wirelessly to one another.
1) Two pumps operate together in constant pressure control.
2) Pump Controller: Determines when to operate a single pump or both pumps to meet demands. While both pumps operate, they will run at the same speed.

8. Interface and Communication:
a. Pump to have an Integrated Operator Interface:
1) Minimum 2.4 inch (measured diagonally) color TFT display.
2) Push Buttons: A quantity of seven for navigation of menu.
a) Must be able to operate 25,000 times.
b) Must be isolated from the main supply by reinforced insulation according to UL 60730.
3) LEDs: Signal pump status for quick indication.

b. Sensor Integrated Directly into Pump Housing: 4 lines; ground, supply, and two signals for differential pressure and media temperature.
1) Sensor Supply: 4.8V DC +/- 2% at 20mA referenced to Ground. Must be able to withstand a permanent short circuit.

c. Pump Module One Analog Input:
1) Configurable for 4 to 20mA or 0-10 VDC input signal for external temperature or pressure sensor, or setpoint influence.
2) Sensor Input: Three wires for ground, supply, and signal.
a) External Analog Supply: Input: 24 VDC +/-10% at 22 mA reference to Ground and able to withstand a permanent short circuit.
b) Connection: Screw terminal capable of wire sizes up to AWG16.

d. Digital Inputs: Galvanically isolated from main supply by reinforced insulation according to UL 60730. Quantity of three inputs.
1) Start and Stop: Pump is enabled when connected to common ground by an external potential free short circuit.
a) An open circuit to this input will disable the pump.
b) Connection: Screw terminal capable of wire sizes up to AWG16.
2) Minimum: Used to force pump to run at minimum load (curve).
a) When connected to common ground by an external potential free short circuit the pump will run at minimum load.
b) Connection: Screw terminal capable of wire sizes up to AWG16.
3) Maximum: Used to force the pump to run at maximum load (curve).
a) When connected to common ground by an external potential free short circuit the pump must run at maximum load.
b) Connection: Screw terminal capable of wire sizes up to AWG16.

e. Pump Module Output Relays: Quantity of two.
1) Configurable for alarm, reading, or operating indication.
2) Each relay must have three screw terminals.
3) Output Relay Contacts Ratings:
a) Maximum: 250 VAC at 2A.
b) Minimum: 5 VDC at 20 mA.
c) Relays must have galvanic isolation from the internal supply by reinforced insulation according to UL 60730.

9. Building Management Systems Integration: Capable of accepting add-on modules for the following BMS:
a. LonWorks.

b. Bacnet IP.
c. MSTP Modbus.
d. Profibus.

Editor's Note: Special materials for components are available to suit the type of liquid pumped. Consult Manufacturer for more detailed information.

C. Vertically Mounted, Split-Coupled, In-Line Pump with Integrated Motor, Drive, and Control:
1. Basis of Design: VLSE as manufactured by Grundfos.
2. Standard product of a single pump manufacturer.
3. Pumps Features:
a. Back Pull-Out Design: Rotating element can be removed from casing without disconnecting suction or discharge piping.
b. Casing:
1) Material: Close-grained cast iron ASTM A48-Class 30.
2) Tensile Strength: 30,000 psi.
3) Volute: Integrally cast suction and discharge connections, gauge ports at nozzles, vents, and drain ports.
a) Material: [Cast Iron ASTM A48 - Class 30] [or] [Ductile Iron ASTM A536- Class 65]
b) Pumps Suction and Discharge: To be the same size.
c) Pumps with 3 inch or Larger Suction and Discharge: To have double volute casing and suction splitter to reduce pre-rotation and improve efficiency.
d) Casings: Designed for scheduled working pressure. Must withstand hydrostatic test at 150% of maximum working pressure under which the pump could operate at design speed.
c. Renewable Case Wear Ring: Tin Bronze ASTM B584-90500.
d. Flanges on Suction and Discharge: Drilled to ANSI Class 125# standards and machined flat face.
e. Pump Shaft: Solid stainless steel AISI 303.
f. Inside Mechanical Seals: As recommended by the pump Manufacturer based on pressure, temperature, and liquid outlined on the equipment schedule.
1) Seals will have ceramic stationary seats, carbon rotating rings, buna elastomers and stainless steel hardware.
2) Application of Mechanical Seals: Internally flushed type, without requiring external flushing lines.
3) Capable of being inspected and replaced without removing piping or volute.
g. Recirculation Line: Nylon tubing with brass fitting provided to vent mechanical seal.
h. Impeller: Enclosed Francis vane type, single suction design. Silicon bronze, ASTM B584 C87600.
1) Hydraulically and dynamically balanced to ISO 1940-1:2003 grade G6.3 and keyed to the shaft.
2) Trimmed to meet the specific hydraulic requirements.
i. Motor Bracket: Cast iron ASTM A48- Class 30.
j. Pump Rotation: Clockwise as viewed from motor end.
k. Coupling Connecting Pump and VFD Motor: Rigid, aluminum, axially split coupling capable of withstanding torsional, radial, and axial loads.
1) Coupling Design: Facilitate alignment of motor and pump shaft. Allow replacement of mechanical seal without requiring drive motor removal.
2) Material: Aluminum 2011-T3, 2017-T4, or 2024-T351.
l. Coupling Guard: OSHA approved, mounted between pump and motor.
m. Maintainable design using machined fit parts that are easily disassembled.
n. Painted with one coat of high quality factory approved paint,
o. Name-plated before shipment from the factory.

Editor's Note: Optional supports. Delete support option not required or delete both.

p. Mounted on a heavy duty cast iron support stand.
q. Mounted on steel flange supports for floor mounting.

4. Integrated Variable Frequency Drive (VFD) Motors:
   a. All motors. To have a VFD, and built-in pump system controller.
      1) Built and tested as one unit by the same manufacturer.
   b. Enclosure Rating: IP55 (TEFC) as a complete assembly.
      1) Motor: NEMA C-Face, Class F insulation with Class B temperature rise.
   c. Variable Frequency Drive:
      1) Pulse Width Modulation (PWM) using up to date Insulated Gate Bipolar Transistor (IGBT) technology.
      2) Convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling motor speed.
         a) Motor Current: Closely approximate a sine wave.
         b) Motor Voltage: Varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate need for motor de-rating.
      3) Radio Frequency Interference (RFI) Filter: Minimizes electrical noise disturbances between the power electronics and power supply.
         a) VFD and Motor: Meet requirements of EMC directive concerning residential and light industry equipment (EN 61800-3).
      4) Two skip frequency bands which can be field adjustable.
      5) Internal solid-state overload protection to trip within the range of 125-150% of rated current.
   d. VFD and Motors:
      1) Include protection against input transients, loss of AC line phase, overvoltage, under-voltage, VFD over-temperature, and motor over-temperature.
      2) The motor overtemperature protection: Consist of three series connected PTC thermistors, one for each motor phase.
      3) Full nameplate output capacity (horsepower and speed) within a balanced voltage range.
      4) Automatic De-Rate Function: The VFD/motor will reduce speed during periods of overload allowing for reduced capacity pump operation without complete shut-down of the system.
         a) Detection of Overload: Based on continuous monitoring of current, voltage and temperature within the VFD/motor assembly.
      5) Input and Output Capabilities:
         a) Two Analog Inputs: 0-10 VDC or 4 to 20 mA.
         b) One Analog Output.
         c) Four Digital Inputs.
         d) Fault Signal Relay (NC or NO).
         e) Fieldbus communication port (RS485).
      6) Motor Drive End Bearings: Sized so L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

Editor's Note: Optional component of the integrated variable frequency drive motor developed and supported by the pump manufacturer.

5. Pump System Controller (Proportional-Integral) and User Interface:
   a. Easy to use interface mounted on VFD/motor enclosure.
      1) Pump System Start and Stop and Set-Point Adjustment: To be possible using two push buttons located on the drive enclosure.
   b. VFD and Motor: Capable of receiving a remote analog set-point (4-20 mA or 0-10 VDC) as well as a remote on/off (digital) signal.
   c. Pump Status and Alarm State: Indicated via two LED lights located on the VFD/motor enclosure.
   d. Advanced Programming and Troubleshooting: Via infra-red handheld programmer or a field connected personal computer.
      1) Pump System Field Adjustable Programming: Include the following.

a) System pressure set-point (psig).
b) System stop pressure (psig).
c) Pressure transducer supply/range.
d) System time, proportional gain.
e) System start pressure (psig).
f) Minimum pump speed, (%).
g) Maximum pump speed, (%).
h) Integral action time.

e. Infra-Red Programmer:
1) Capable of displaying the following status readings:
a) Pump Status (on, off, min., max.).
b) Actual system pressure (psig).
c) Pump speed (rpm)
d) VFD/Motor total cumulative (kWh)
e) System Set-point (psig)
f) Remote set-point (%)
g) VFD/Motor input power (kW)
h) VFD/Motor total operating hours
2) Capable of displaying the following alarms. The last five alarms stored in memory:
a) Loss of sensor signal.
b) Under-voltage and over-voltage.
c) Motor over-temperature.
d) Drive over-current.
e) Loss of external set-point signal.
f) Motor overload (blocked pump).
g) Drive over-temperature

f. Control Modes:
1) Proportional Differential Pressure: Constant curve.
2) Constant Differential Pressure: Constant flow.
3) Constant Pressure: Constant temperature.
4) Constant level.

g. Sequence of Operations:
1) System controller receives analog signals [**4-20mA**] from the transducer indicating the actual system pressure, flow, level, etc.
2) As Demand Changes: VFD and motor increases or decreases speed until the system matches the system set-point.

h. Pressure Transducers: Made of 316 stainless steel.
1) Manufactured by Grundfos.

Editor's Note: The transducer on the pump discharge is optional. Delete if not required

2) Factory installed on pump discharge side with copper tubing.
3) Installed on motor by manufacturer. Electrical Connection to be finalized in factory.
4) Transducer Accuracy: +/- 1.0% full scale. Hysteresis and repeatability no greater than 0.1% full scale.
5) Output Signal: 4 to 20 mA.
6) Supply Voltage Range: 0-10 VDC.

2.6 DISTRIBUTED PUMPING SEQUENCES OF OPERATION AND INTEGRATION

A. Distributed Pump for One Air Handling Unit (AHU): Dedicated distributed pump in Closed Loop Control.
1. Normal Distributed Pump Operation: Control mode; constant temperature.
a. Distributed Pumps: Self-regulating devices than maintain a discharge air temperature by modulating pump speed.
1) Discharge Air Temperature (DA-T): Set with adjustable setpoint in the pump

2) DA-T Sensor: Connected to pump via analog 4-20 mA signal.

2. Events Requiring Distributed Pump to Operate:
   a. Events: AHU Fan must be ON. DA-T: Above the setpoint.
   b. BMS via Fieldbus or Digital output (DO): Starts distributed pump, changing operating mode to "Normal."
3. Events Requiring Reduced Distributed Pump Operation Events: Caused by AHU alarm.
   a. Freezestat: Low temperature Alarm (LT-A). Prevents coil from freezing.
   b. Freezestat Events: Require a minimum flow thru the cooling coil.
      1) Low Temperature Alarms: Distributed pump automatically reduces its speed to a fixed setpoint and will run at minimum speed of 20%.
      2) BMS has no need to stop the distributed pumps.
4. Events Requiring Distributed Pump to Stop:
   a. Economizer Function: Free cooling using cold outside air:
      1) BMS via Digital output (DO), Stops distributed pump, changing operation mode to "Stop."
   b. AHU Alarms Modes Where Fan Stops:
      1) Fan failure
      2) High Static Pressure
      3) Low Static Pressure
      4) Smoke detection.

B. Distributed Pump for One Air Handling Unit (AHU): Dedicated distributed pump in Open Loop Control.
   1. The BMS operates and regulates the distributed pump. The BMS adjusts the distributed pump speed via its proportional integral derivative (PID) control to maintain the adjustable discharge air temperature (DA-T) setpoint.
      a. Distributed Pump Speed: Setpoint is set by BMS, 0 to 100%, to match the (DA-T).
      b. DA-T Sensor: Connected to Direct Digital Controller (DDC) via an analog input.
   2. Events Requiring Pump to Operate: Change distributed pump operation mode to "Operate". Prerequisite: AHU fan must be "ON."
      a. BMS via Fieldbus: Starts distributed pump at any given time.
      b. Digital output (DO): Starts distributed pump at any given time.
   3. Reduced Pump Operation Events: Caused by AHU alarm.
      a. Freezestat: Low temperature Alarm (LT-A). Prevents coil from freezing.
      b. Freezestat Events: Require a minimum flow thru the cooling coil.
         1) Low Temperature Alarms: BMS must set a minimum speed setpoint for the distributed pump; proposed to be 10% of nominal speed.
            a) Once Temperature Exceeds LT-A Setpoint: BMS must regain normal operation by setting a 0 to 100% speed signal to distributed pump to maintain DA-T setpoint
         2) BMS has no need to stop the distributed pumps.
   4. Events Requiring Pump to Stop:
      a. Economizer Function: Free-cooling using cold outside air.
         1) BMS via Fieldbus or Digital output (DO): Will stop distributed pump by changing its operation mode to "Stop".
      b. AHU Alarms Modes Where Fan Stops: BMS via Fieldbus or Digital output (DO): Will stop distributed pump by changing its operation mode to "Stop".
         1) Fan failure.
         2) High static pressure.
         3) Low static pressure.
         4) Smoke detection.

C. Distributed Pump for More FCUs, Headered: Distributed pump in Closed Loop Control with Internal Sensor.
   1. Normal Distributed Pump Operation: Control Mode: Proportional pressure.
      a. Distributed Pump: Operates as self-regulating device.

1) Pump Speed: Modulated based on feedback signal from pump's built-in internal sensor to maintain the proportional pressure setpoint to reach the pressure and flow duty point for all headered FCU's in operation.
a) Proportional Pressure Setpoint: Adjustable. May be set at the pump or set at the BMS

2. Events Requiring Pump to Operate:
a. One or more FCU's are ON at any given time.
1) BMS via Fieldbus: Set distributed pump to operation mode "Normal."

3. Events Requiring Pump to Stop
a. All Headered FCU's Are Off:
1) Distributed pump pressure is reduced at decreasing flow demand. Pressure will be half the setpoint.
b. All Served FCU's Are Off:
1) BMS via Fieldbus: Change operation mode to "Stop" stopping the distributed pump.
c. Other System Alarms:
1) BMS via Fieldbus: Change operation mode to "Stop" stopping the distributed pump.

4. Distributed Pump in Alarm: Pump is stopped.
a. FCU fan must continue current speed.

D. Distributed Pump for More FCUs, Headered: Distributed Pump in Closed Loop Control with External Sensor:
1. Normal Distributed Pump Operation: Control Mode; Constant Pressure)
a. Distributed pumps are self-regulating devices.
b. Pump modulates it's speed to maintain the adjustable differential pressure setpoint with a feedback signal from the external sensor. Pressure setpoint must be set according to the critical point.

2. Events Requiring Pump to Operate:
a. One or More FCU's are ON at Any Given Time:
1) BMS via Fieldbus: Change operation mode to "Normal." Start distributed pump.

3. Events Requiring Pump to Stop:
a. All Headered FCU's are Off:
1) BMS via Fieldbus: Change operation mode to "Stop." Stop distributed pump.
b. Other System Alarms: Any system alarms occurs.
1) BMS via Fieldbus: Change operation mode to "Stop." Stop distributed pump.

4. Distributed Pump in Alarm: Pump is stopped.
a. FCU fan must continue current speed.

E. Primary Pumps Controller "Closed Loop Control":
1. Normal Primary Pump Operation
a. System Controller: Operates equal sized variable speed pumps.
1) Primary Function: Maintain minimum flow for active chillers via signals from pressure differential sensors at each chiller.
a) Signal to Pumps: 4-20 mA signals from pressure differential sensors at each chiller
2) Secondary Function: Ensure primary flow on the production side is balanced to total flow from distributed pumps on the distribution side.

Editor's Note: Grundfos recommends 4 temperature sensors.

a) Signal to Pumps: 4-20 mA from 4 temperature sensors, T1 to T4, from bypass pipe
b) Signal to Pumps: 4-20 mA from 2 temperature sensors, T1 to T4, from bypass pipe

b. Optimal Cascade Control: Determines number of primary pumps to operate to fulfill demand:

1) Ensures the Following: Chiller safety is always priority 1.
   a) Minimum flow to chillers
   b) Balanced flow on primary and secondary side.

c. Optimal Sequencing of Pumps:
   1) Based on pump characteristics derived during a fully automatic pump parameterization done for each pump.
      a) Controller: Automatically stages the most efficient number of pumps to ensure lowest possible energy consumption.

2. Alarms and Warnings Pump Control:
   a. Control MPC will raise a warning, if a specific primary pump is not delivering adequate flow.
3. Automatic Alternation:
   a. All Primary Pumps in System: Alternate automatically based on demand, time and fault.
      1) Continuous Flow Demand (no flow shut-down occur): Adjustable system controller to have the capability to alternate pumps every [**24**] [**48**] hours [**or**] [**once per week**].

2.7 PUMP SYSTEM FACTORY TESTING

A. Tester for Testing Pump System: Constructed and calibrated according to requirements of hydraulic test standard ISO 9906.

B. Entire Pump Station: Factory tested for functionality. Documented results of functionality test supplied with pump station.

C. Functionality Testing: Include the following parameters.
1. Complete System Hydrostatic Test: 1.5 times the nameplate maximum pressure,
2. No-Flow Detection Shutoff Test.
3. Water Shortage Test.
4. Two-Point Setpoint Performance Test.

D. Water Used for Testing: Treated with three different filtration systems to ensure only clean water is used for testing pump station.
1. 25 Micron Mechanical Filter: Removes solid parts from water.
2. Activated Carbon Filter: Keeps water clear and eliminates odor.
3. Ultraviolet Light System: Kills all bacteria growth.

E. Optional Performance Testing:

Editor's Note: Delete the two options below not required.

1. 10-Point Verified Performance Test.
2. Witnessed Verified Performance Test.
3. Remote Witnessed Verified Performance Test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect the packaged system. Report any obvious damage.

B. All substrates to be properly installed prior to pump system installation.
1. Notify in writing, the Engineer of Record if substrates and foundation is not acceptable for pump system installation.

3.2 PREPARATION

A. Prepare substrates for installation according to Manufacturer's recommendations.
   1. Verify pump foundations have been properly installed and are prepped and ready to receive pump systems.

3.3 INSTALLATION

A. Install Pumping System according to Manufacturer's written instructions.

B. Variable Speed Packaged Primary Pumping System
   1. Installer's Responsibilities:
      a. Installation Services: Off-load, store, locate, level, anchor, pipe and wire the system and the remote components.
      b. Inspecting and tightening mechanically fastened connections.
      c. Flushing and filling each system.
      d. Field connections to the unit including piping, electrical and drainage.
      e. Control instrumentation that has been shipped loose.
         1) Includes but not limited to the following:
            a) Pressure and temperature transmitters.
            b) Flow meters.
            c) Associated wiring for each unit.
      f. Supply and install life safety equipment as needed.
      g. Equipment accessories shipped loose from factory.
      h. Applying for and securing all proper local permits.
      i. Providing and installing the main power feeds.

C. Align pump and motor shafts to within manufacturer's recommended tolerances prior to system start-up and other equipment alignment.

D. Distributed Pumps
   1. Pump Shaft: Installed horizontally per manufacturer's recommendations.
   2. Terminal Box: Located per manufacturer's recommendations.
   3. System to be vented out at location higher than the pump.
   4. Required inlet pressure by the pump shall be available at the pump inlet.

E. Variable Speed Vertical In-Line Pump:
   1. Pump Shaft: Installed horizontally per manufacturer's recommendations.
   2. Terminal Box: Located per manufacturer's recommendations.
   3. System to be vented out at location higher than the pump.
   4. Required inlet pressure by the pump shall be available at the pump inlet.

F. Vertically Mounted, Split-Coupled, In-Line Pump with Integrated Motor, Drive, and Control:
   1. The pump shall be installed per manufacturer's recommendations and according to the standards of the Hydraulics Institute

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Manufacturer is to supply a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
   1. Prepare test and inspection reports.

3.5 CLEANING

A. Touch up paint scratches, and repair minor dents and imperfections that may occur during hoisting and rigging.

END OF SECTION