**­­Design Envelope 4000 Variable Primary  
Flow Integrated Pumping System**

File No: 90.166

Date: August 04, 2022

Supersedes: 90.166

Date: January 31, 2019

Typical Specifications

**Multi-zone pump set controller for primary heated or chilled water system**

1. GENERAL
   1. SCOPE – MULTI-ZONE PUMP SET CONTROLLER DESCRIPTION
      1. This specification applies to the control of a multiple pump HVAC heated and/or chilled water systems that involves up to eight (8) *{select one of the following} {headered variable speed primary pumps} or {dedicated variable speed primary pumps}* allowing for all duty and duty/standby configurations. The system has \_\_ (*qty*) variable speed primary pumps with integrated controls and capable of providing their flow and head calculated from electrical variables,

*{The following applies only if the pumps aren’t controlled using Parallel SensorlessTM} {Select one of the following} {supplying heated or chilled water to \_\_ (qty) zones, whose demand is measured by {differential pressure} or {return temperature} sensors}.*

*{The following applies only if the pumps are controlled using both Parallel SensorlessTM and critical zone sensors (Hybrid)} {Select one of the following} {supplying heated or chilled water to \_\_ (qty) zones, in which \_\_ (qty) zones are critical whose demand is measured by {differential pressure} or {return temperature} sensors}.*

* + 1. The controller shall be supplied with all the hardware, software and programming required to control up to eight (8) variable speed primary pumps and up to sixteen (16) zone demand sensors (which can either be differential pressure or temperature sensors).
    2. The quantity of pumps and zone sensors to be controlled shall be independently configurable on-site at the graphic user interface by selection from button-based menus, without requiring reprogramming or software download. All schematics, tables and menus in the graphic user interface shall show only the data and graphics corresponding to the selected configuration.
    3. Only the field sensors (temperature, flow, differential pressure, etc.) shall be supplied in the quantities required by the configuration in paragraph A, except as indicated in the Spares section.
    4. The controller shall be supplied with all the hardware, software and programming required to be seamlessly integrated with the reporting and remote read-write capabilities of the building automation system (BAS). The pump set controller shall allow field adjustments of control parameters as described below.
  1. RELATED SECTIONS
     1. Section 25 50 00 - Integrated Automation Facility Controls
     2. Section 23 64 00 - Package Water Chillers
     3. Section 23 52 00 – Heating Boilers
     4. Section 23 20 00 - HVAC Piping and Pumps Plumbing Systems
     5. Section 23 09 00 - Instrumentation and Control for HVAC
  2. STANDARDS REFERENCES AND QUALITY ASSURANCE
     1. The controller shall be assembled with components that conform to the latest edition of the following as applicable:
        1. ANSI – American National Standards Institute *{delete if not applicable in your market}*
        2. NEMA – National Electrical Manufacturers Association {delete if not applicable in your market}
        3. UL – Underwriters Laboratories {delete if not applicable in your market}
        4. CSA – Canadian Standards Association {delete if not applicable in your market}
        5. IEC – Degrees Of Protection Provided By Enclosures (IP Code) {delete if not applicable in your market}
        6. ASHRAE 90.1-[2013] - American Society of Heating, Refrigeration and Air-Conditioning Engineers – Energy Efficient Design of New Buildings
        7. ASHRAE 100 - American Society of Heating, Refrigeration and Air-Conditioning Engineers – Energy Efficient Design of Existent Buildings
        8. The pump set controller manufacturer must hold an ISO 9000 QA certification or approved equal.
  3. INSTALLATION AND CONTROL CONTRACTOR RESPONSIBILITIES
     1. The controls contractor is responsible for the following:
        1. Inspect interior and exterior and report any obvious damage or equipment shifting that may have taken place between the time the unit arrived on site and when in its final resting position
        2. Mechanical installation of the control package and mount in place. Re-align and level the control panel(s).
        3. Install all life safety equipment as needed.
        4. All field electrical connections to the unit. Hook up electrical supply needed by the plant pump set controller (including field sensors). Connect with the BAS and confirm that BAS is ready to send/receive commands to the pump set controller. Provide internet connection to the automation system.
        5. Field connect equipment including pressure/temperature sensors, flow meters and their associated wiring to the unit (a list of field installed equipment will be supplied, along with installation instructions). As required by device instructions, where necessary, calibrate all sensors and auto valves.
        6. Touch up and paint scratches and minor dents occurred during hoisting and rigging
        7. Permits and inspections needed to start up the system
        8. Start-up of system with the supervision of manufacturer personnel
  4. SUBMITTALS
     1. Provide a complete controller Submittal with all requirements as defined in the GENERAL requirements of these specifications. As a minimum, the Submittal shall include the following:
        1. Dimensional drawings of the main components, also indicating weight and any special hoisting or working space clearances requirements
        2. Description of system operation
        3. Electrical power and control wiring diagram
        4. Control layout drawing with sequence of operation
  5. Operation and maintenance manuals
     1. As a minimum, the Operation and Maintenance Manual shall include:
        1. System summary sheet
        2. Description of system operation, with equipment and control sequence of operation
        3. Electrical power and control wiring diagrams
        4. Installation and maintenance manuals from equipment manufacturers
        5. Snapshots of all graphic user interface screens, with description of all variables and recommended tuning values or tuning methods.
        6. Submittals and operation and maintenance manuals shall be assembled in a neat and orderly manner and bound in booklet form. Include a front page that identifies the job particulars followed by a table of contents.
  6. START-UP, COMMISSIONING, WARRANTY AND SERVICE
     1. The start-up and commissioning will be by a local factory authorized service provider who is fully supported by Armstrong factory staff remotely.
     2. Warranty period: One (1) year parts and labour warranty (two years with warranty registration)”.

1. PRODUCT
   1. MANUFACTURERS
      1. Acceptable Manufacturer: The integrated pumping system (IPS) pump logic controller shall be Armstrong IPS Controller 4000 series, by Armstrong Fluid Technology.
      2. Substitutions: Not permitted.
   2. HARDWARE
      1. PUMP CONTROLLER and Associated Equipment
         1. The controller shall be a stand-alone system capable of operating independently of the building automation system (BAS), and at the same time capable of receiving remote instructions from the BAS.
         2. The pump set controller shall be performed solely by the PLC and the Graphic User Interface shall not be required for plant operation, other than initial setup or configuration.
         3. The controller shall include:
            1. An internal circuit breaker
            2. Multi-color 4.3” back-lit touch-screen for all necessary user interface functions. Keypad based interfaces, LCD readouts, and LED displays will not be accepted.
            3. Operation temperature range: 0°C to 50°C (32°F to 122°F) (must not be exposed to direct sunlight)
            4. Operation humidity range: (10% - 85%) non-condensing
            5. Ambient air temperature for storage: -20°C to 70°C (-4°F to 158°F)
            6. Power supply: AC 100-240V, 500 W
            7. {select one of the following or delete if not applicable in your market} {UL mark, FCC compliant} or {CE mark, EN 61000-4-3 compliant}
         4. The pump set controller shall have a key lockable {select one of the following} {NEMA 12} or {NEMA 4X} or {IP54} or {IP55} rated cabinet. All operator interface control switches, indicators and displays shall be physically separated from any field terminations. Switches and indicators must be protected from unauthorized operation by a key lockable door.
         5. The controller shall have Hand-Off-Automatic (H-O-A) control and provide the option for a remote on/off signal from a Single dry type relay or via BMS serial communication signal. These virtual H-O-A switches shall be accessible through the touch screen display, and in Hand mode, the controller shall allow the pump speed to be manually set and changed.
      2. SCREEN
         1. The pump set controller shall include a back-lit touch screen color display operator interface of at least 4.3” and show active-element schematic displays with links to sub-menus for status reports, data and setup menu options. Keypad based interfaces, LCD readouts, and LED displays will not be accepted. The pump logic controller shall perform online self-diagnostic testing of the CPU(s), RAM, and flash memory. No data shall be lost during power supply interruptions.
         2. The pump set controller shall be self-prompting. All messages shall be displayed in plain English and support for display of multiple languages and characters simultaneously. The operator interface shall have storage memory at least 500 faults and be able to recall them on the screen, on-screen help functions, and separate user screens for:
            1. Detailed view of the system of primary pumps and {select one of the following} {chiller} or {boiler} quantity, mode and status, system flow, dynamic minimum and maximum flow, bypass valve % opening, deviation from the control curve (sensorless mode) or from the active zone (with zone sensors)
            2. System zones overview with setpoint, status and active zone deviation
            3. Up to sixteen (16) zones setup with one dP (differential pressure) or temperature sensor per zone
            4. Up to eight (8) pumps overview with their mode, status, speed (% and rpm) and total run time
            5. Detailed view of each pump with actual run hours, hand speed % and power consumption, and Hand-Off-Automatic (H-O-A) control
            6. Pump setup to configure the number of duty pumps (with option for up to one stand-by pump), lead pump switch & minimum running time and drive settings
            7. Pump speed setup with minimum, maximum and default speed, pump rated rpm and speed ramping
            8. Sensorless overview completing the pump overview with individual and system flow and head
            9. Sensorless setup for flow and head at Best Efficiency Point (BEP), dead band, flow and head design, zero flow head.
            10. PID setup for the pump speed control based on selected cooling or heating mode
            11. Temperature control overview monitoring the valve position (%), the temperature sensor setpoint & present values, and sensor status (not available on IPS 4501w)
            12. Temperature control setup with adjusting the P/I control parameters, the valve output type (0-10V or 2-10V), temperature sensor zero and range (4-20mA output as reference), valve maximum allowable opening (%) and PID action (not available on IPS 4501w)
            13. Bypass valve overview monitoring the valve position (%), actual system flow (from flow meter or sensorless readout) and {select one of the following} {chiller} or {boiler} minimum & maximum flow rates dynamically based on number of equipment enabled
            14. Bypass valve setup adjusting the P/I control parameters, the valve output type (0-10V or 2-10V), the valve minimum and maximum positions and ramp time setting (seconds)
            15. Optional BAS (Building Automation System) communication setup with protocol, address, baud rate, and parity selection
            16. System valves control setup, if enabled, to maintain the position of the most open system valve at the optimum opening setpoint by adjusting the active zone setpoint
            17. VFD readout setup to scale values read from VFD
            18. Flow setup, obtained from a sensor or by sensorless reading, flow range and min/max flow rate from BAS or per {select one of the following} {chiller} or {boiler} in local source.
            19. Current alarm list and alarm history
            20. PLC diagnostic with current state and information of the PLC, HMI, and BAS protocol
      3. INSTRUMENTATION
         1. Temperature sensors, pressure sensors and flow meter listed in the Annex shall be installed by the contractor as indicated in the shop drawings to modulate the chilled water system.
         2. Temperature sensors shall be self-contained RTD type temperature transmitter with a temperature range of (-400 to 1076°F) (-240 to 580°C) for chilled water systems designed to meet NEMA-4X (IP66) construction. The temperature probe shall use a platinum, wire wound, sensing element in a 316SS sheath, spring loaded and inserted into a ½” NPT stainless steel thermo well. The thermo well shall penetrate one-half the pipe diameter. The two probes of the supply and return temperature sensors shall be matched pair. Sensors shall not be locally adjustable. The accuracy of the temperature sensor shall be 0.5% of span and shall be calibrated and traceable to NIST. The temperature transmitter shall receive its power input and send its current output, 4-20 mA, over the same pair of low voltage wires. Sensors shall be mounted such that effects of radiation from heating elements are minimized and rapid response to changing temperature is achieved. The stability of the transmitter/probe assembly shall be +/0.001% of span/100 Ohms of lead resistance. Wiring installed by the contractor between the pump set controller and the transmitters shall be Belden 9320, 2-wire, shielded, twisted cable (or equivalent) and shall not be placed in conduit containing wiring for alternating current. Supply and return temperature sensor shall be field installed and wired by the contractor between the chillers and the bypass line.
         3. Pressure sensors shall be complete, self-contained, variable capacitance type, stainless steel construction differential pressure transmitters designed to meet NEMA-4X (IP66) construction and provide a 4-20 mA signal output. The accuracy of the pressure sensor shall be 0.5% of span including linearity, hysteresis and repeatability. Wiring terminals and electronics shall be in separate compartments, so the electronics remain sealed during installation. Reverse polarity protection shall be included to keep wiring mishaps from damaging the transmitter. Wiring between the pump set controller and the transmitters, provided by the installing contractor, shall be Belden 9320, 2 wire, shielded twisted cable (or equivalent) and shall not be placed in conduit containing AC electrical wiring. Pressure switches shall have adjustable ranges and adjustable differentials to suit the application. Pressure sensor shall be field installed and wired by the contractor.
         4. The flow sensor shall be a high precision magnetic flow meter with no moving parts. Paddle and turbine type sensors will not be accepted. The sensor shall have a maximum operating pressure of 300 psi, operating temperature range of 5°F to 158°F. Accuracy shall be within 0.5% of actual reading at the calibrated typical velocity and within +2% of reading over 200:1 turndown (from 0.05 to 10 m/s). Provide certificate of calibration with each flow sensor. The sensor shall have integral 4-20mA analog output linear to within +0.1% of calibrated span for connection to the pump set controller. The flow sensor shall be constructed of stainless steel with NEMA 4 (IP65) protection. Contractor shall supply hot tap installation, in order to be both insert able and removable through a ball valve when the pipe is under pressure. Flow meter shall be field installed and wired by the contractor. The sensor shall be field mounted and wired in accordance with manufacturer’s instructions.
      4. SOFTWARE
         1. Capabilities: The pump set controller software shall be preprogrammed to perform, but will not be limited to the following:
            1. Manual or automatic pump set controller
            2. Duty cycling
            3. Automatic lock-out of malfunctioning equipment
            4. Backup sequences of control for any sensor failure
            5. Primary pumps control to satisfy the system demand
            6. Control sequences for dedicated and for headered pumps
            7. Optimized sequencing of the Chilled or Heated Water pumps
            8. Control sequences for Parallel Sensorless™ and zone sensors distribution pump speed control options
            9. Maintain minimum flow through the {select one of the following} {Chiller} or {Boiler}
            10. Monitoring the status of the isolation valve to determine the system minimum and maximum flow.
            11. Setpoints reset based on most open load valve
            12. Scanning and alarm processing
            13. Graphic screen reporting
         2. User Friendliness: The pump set controller software shall be easy and intuitive to operate. Operators shall be able to perform the following operations after 4 hours day of training:
            1. View systems parameters
            2. Select relevant screens, systems and points
            3. Turn on and off controlled points manually
            4. Acknowledge alarms
         3. Input/Output: A complete point schedule shall be provided detailing analogue and digital input and output point description, functions, types and any special requirements. The pump set controller shall be capable of accepting and processing appropriate signals (Differential Pressure, Temperature, or Flow) for the following dedicated terminal blocks:
            1. Up to sixteen (16) analog inputs (AI) for zone differential pressure or zone temperature signals (4-20 mA)
            2. Up to eight (8) digital inputs (DI), one per {select one of the following} {chiller} or {boiler} status
            3. One DI for remote connection for start/stop
            4. Up to eight (8) DIs, one per pump, for fault signal (not available on IPS 4501w)
            5. Up to eight (8) analog outputs (AO), one per pump, for speed reference signal
            6. Up to eight (8) digital outputs (DO), one per pump, for start signal
            7. One DO for general system alarm
            8. One DI for emergency stop
            9. Up to eight (8) DIs, one per pump, for run feedback
            10. One AI for system flow meter
            11. One DO for bypass valve
            12. One serial port for optional communication interfacing with a Building Management System (BMS/BAS)
            13. One serial port for standard communication between the controller and VFD's through serial Modbus protocol (Analog/Digital Input/Outputs available for hardwired control of VFD's)
            14. One terminal block for power supply 100V-240V AC / 50-60 Hz
         4. Trending and Reporting Capabilities: The controller provides a log of alarms, and events. The controller shall be capable of displaying the alarm history on its graphical touchscreen.
         5. The pump set controller shall display live data on demand. The pump set controller shall provide graphic screens of system schematics.
         6. Communication Protocol: The pump set controller shall be able to communicate with the Building Automation System with one of the following protocols: Modbus RTU, BACnet MS/TP or BACnet IP.
         7. The pump set controller shall allow changes in the field of the network address, baud rate and parity it uses to communicate with the BAS. Network addresses cannot be hard coded.
         8. Remote Access: The pump set controller shall include webserver functionality and be accessible through an internet TCP/IP internet address, or potentially through a cloud server, with read/write functionality. This access shall allow the relevant staff to:
            1. Remotely view all screens available at the local graphic user interface (GUI), with the same functionality. I.e.: view plant status, view and modify parameters and set points, override equipment and navigate screens.
            2. View all available live and historic data
            3. Receive alarm messages, automatically processed and conveyed via the network.
            4. BAS and Internet connection shall be provided by others, but the controls contractor installing the pump set controller is responsible of requesting it and coordinating with the IT contractor.
            5. Remote manual override by the BAS shall be possible for the following equipment settings:

Pump set controller ON/OFF

* + - 1. Alarms: Alarms shall be generated and the alarm messages shall be displayed in clear textual form on the screen, until it is acknowledged by the operator. Alarms shall include but not limited to the following list:
         1. General alarm
         2. Pump alarm
         3. Emergency alarm
         4. Pumps run feedback, no flow, communication and drive fault alarms
         5. Zone and flow transmitters failed alarms
         6. All zones failed alarm
         7. Flow, temperature sensor failed alarm
         8. Chiller/boiler above maximum flow and below minimum flow alarms
         9. One free contact shall be provided for general alarm
      2. Safety Features shall include but not limited to the following list:
         1. Auto omission of pump in case of pump failure
         2. Auto omission of zone/sensor in case of any zone sensor failure
         3. Backup sequences in case of flow sensor failure, temperature sensor failure, and all zone sensors failure
         4. Deadhead protection when no flow
         5. Indication of any Failure (or) malfunctioning in the touchscreen screen user interface, the remote access screens, in the BAS communication.
         6. Remote stop for emergency shutdown
      3. Access Security: The pump set controller shall have at least four (4) levels of password security:
         1. Level zero: view only
         2. Level one: modifies all parameters visible on the touchscreen except pump PID and BAS, set equipment in Hand mode and restore previously saved default values
         3. Level two: modifies all parameters and save changes
         4. Level three and four: access with a branded workbench and secured authorization only
      4. Sequence of Operation:
         1. All pump set controller settings, including the number of pumps, as well as how they are connected (headered or dedicated) can be modified at the graphic user interface (GUI) after entering the appropriate password.
         2. The pump set controller determines the most efficient combination of operating pumps, and pump operating speed based on the zone differential pressure/temperature sensor signals and/or Parallel Sensorless™ as per the field adjustable configuration.
         3. The control system shall continuously monitor all zone signals to determine an active control zone. Use of a multiplexer for multiple sensor inputs is not acceptable.
         4. The pump set controller shall respond to an increase in demand by increasing either: the number of operating pumps or the pump speed.
         5. In the case the demand decreases, the pump set controller shall respond by decreasing either: the number of operating pumps (or) the pump speed to optimize the energy efficiency of the pumping operation while meeting system demand.
         6. The control system shall automatically disable any zone differential pressure or temperature signals that are not within limits and alert the operator of a possible transmitter failure. If system found all differential pressure/temperature sensors failure in the building, the pump speed will default to a pre-defined percent of full speed (factory default loaded as 95% of full speed).
         7. The pump set controller shall include a modulating valve control capability based on one of the zone temperature inputs of the pump set controller. The valve position is controlled by PID through the pump set controller to maintain the temperature at a set point specified by the user. The valve output shall be selectable between 0-10 VDC and 2-10 VDC.
         8. The pump logic pump set controller shall rotate the pumps based on a field adjustable interval of operating hours with a “bump-less” transfer algorithm. The logic controller incorporates embedded logic to prevent hunting, pump flow surge, and motor overloading.
         9. If any VFD/pump unit fails, the unit shall be locked out in alarm and the appropriate alarm signal shall be activated. In place of the failed assembly, the next available VFD/pump unit shall be operated.
         10. The pump set controller shall modulate the bypass valve to maintain the minimum flow required by the operating {select one of the following} {chillers} or {boilers}.
         11. The pump set controller shall either determine the minimum and maximum flow of all enabled Chillers/Boilers or obtain the values directly from the BAS. It shall adjust the pump number, speed and/or the bypass valve position in order to maintain the flow between those limits.
         12. The pump set controller shall provide End-of-Curve (EOC) protection based on Parallel SensorlessTM (sensorless pumps) or pump operating speed (non-sensorless pumps).
         13. Manual operation mode (for commissioning): When the pump set controller is switched to the manual operation mode by the operator, there is no automatic operation or sequencing of any pump, and operation of chilled water distribution pumps shall be manually set. When operation mode is switched back to auto, the automatic operation mode is restarted.
      5. The pump set controller shall be capable of providing parallel primary pump station control for speed and sequencing of pumps using one or more of the following methods:
         1. Remote zone differential pressure (dP) sensor
         2. Local pump station dP sensor with simulated quadratic control curve
         3. Zone return temperature sensor and/or
         4. Sensorless pump speed and Parallel Sensorless™ pump staging

1. EXECUTION
   1. ELECTRICAL WIRING AND INSTALLATION
      1. The wiring for data communication between sensors, pump set controllers and valve actuator shall be shielded so as not to be susceptible to electrostatic, magnetic, mode and cross talk noise. Electrical wiring shall conform to the requirements of the electrical services section of the specifications and the local electrical code.
   2. TESTING
      1. Upon completion of all systems startup and checkout procedures and while the mechanical systems are being monitored and controlled in a “normal operating” condition, the manufacturer and the facility personnel shall jointly demonstrate the performance of the complete system to maintain flows, temperatures, levels and pressures for 7 days, with no alarms. The test must meet the particular building’s design requirements to be considered passed and acceptable. Any failures or alarms shall require the test to be restarted.
   3. CALIBRATION AND COMMISSIONING
      1. The pump set controller shall be commissioned and fully operational after delivery to the site at the practical date agreed with the building owner representative on-site. Commissioning procedure shall conform to the “Mechanical Services” section of these specifications.
      2. The calibration and commissioning procedure shall consist of validating field I/O calibration, loop checks, actuator stroking and integrated system operation validation. All commissioning information shall be documented on commissioning data sheet forms which shall be submitted to the commissioning agent, if available, or the facility personnel for approval prior to testing. Notify the facility personnel of the testing schedule so that operating personnel may observe calibration and commissioning.
   4. TRAINING
      1. The pump set controller manufacturer shall instruct the personnel of the facility in the operation of the pump set controller. Drawings, operation and maintenance manuals are to be provided to the customer in a single binder, clearly indexed.

END OF THE SECTION

MINIMUM REQUIREMENTS TO OTHER SYSTEMS

CHILLER SPECIFICATION

The chillers shall have variable speed compressors {*select the following if applicable*} {with variable speed drives (VSDs)} and shall be capable of capacity turndown to provide less than 41% of full load capacity by way of compressor {*select one of the following*} {speed control} or {slide valve} or {refrigerant bypass} and without adjustment to the compressor inlet guide vanes.

The chillers shall include their own pump set controller such as to optimize their speed for a given chilled water supply set point and outdoor temperature that may range from 45°F to 120°F.

The chiller shall accept external demand limiting instructions through serial communication signals.

The chiller proposal shall include operating chiller data from 10% to 100% of rated full load in 10% increments at the following constant outdoor dry bulb temperatures (95°F, 85°F, 75°F, 65°F, 55°F).

The chiller shall have a flow turndown to less than 50%.

The chiller controller must be capable of communicating through one of the following protocols: Modbus RTU, Modbus TCP, BACnet MS/TP or BACnet IP.

PLANT DESIGN SPECIFICATIONS

The chilled water plant shall be an air- or water-cooled variable speed plant with {indicate the quantity} \_\_ (qty) identical variable speed chillers and \_\_(qty) identical variable speed distribution pumps *{Delete if not applicable},* \_\_(qty) identical towers with variable speed fans and one drive per tower, and \_\_(qty) identical condenser pumps.

The plant configuration shall provide on the chilled water side {select one of the following} {headered distribution pumps and headered chiller} or {a dedicated {dual-arm} or {twin} or {single} pump to each chiller} and a system decoupler line with a 2-way bypass valve sized to provide the minimum flow required by one chiller when the pump head is 40% of design head. The plant shall supply a single distribution line from the supply header, and receive a single return line from the loads.

*{Delete if not applicable}* On the condenser side, the plant configuration shall be {select one of the following} {headered towers, headered condenser pumps and headered chillers} or {headered towers and a dedicated {dual-arm} or {twin} or {single} pump to each chiller}. The plant shall supply a single pipe from the towers header to the condenser pumps header. The bypass line(s) shall be installed between the supply and return lines and shall not have ends in the headers.

CHILLED WATER SYSTEM PUMPS SPECIFICATION

The chilled water system distribution pumps shall be Armstrong Design Envelope™ variable speed pumps sized to provide in total \_\_% of the plant design flow at their design head.   
{*Note: If there are two headered pumps sized for 100% of the design flow and one fails, the other one is capable of providing about 80% of the design flow over the same system curve, delivering about 95% of the design cooling energy with 3 headered pumps, 2 can supply about 90% of the design flow, or 98% of the cooling energy*}

COOLING TOWER SPECIFICATIONS

The cooling tower shall include fans that will operate safely on variable frequency drive power supplies and all resonant operating frequencies shall be clearly communicated with the proposal for known supply frequency, rotational speed and or carrier frequency.

The cooling tower shall be capable of operating with a flow turndown of 60% of full design flow or less without the use of orifices or reduction in air water surface area, by way of cooling tower pump flow/speed modulation. The cooling tower shall have a serial communication cable.