**Design Envelope 9511 Integrated Plant**

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**Control System**

Typical Specifications

**Air cooled chilled water plant automation**

1. GENERAL
   1. SCOPE – AIR COOLED CHILLED WATER PLANT CONTROL SYSTEM DESCRIPTION
      1. This specification applies to the automation of an Air-Cooled Chiller Plant, which has \_\_ (qty) identical Air cooled Chillers in parallel, and {select one of the following} {\_\_(qty) headered variable speed primary pumps} or {\_\_(qty) dedicated variable speed primary pumps} or {\_\_ (qty) constant speed primary and \_\_ (qty) headered variable speed secondary pumps}, {the following applies only if the pumps aren’t controlled using Parallel Sensorless™}{select one of the following} {supplying chilled water to \_\_(qty) zones, whose demand is measured by {differential pressure} or {return temperature} sensors}.   
         {If the system has both variable speed primary and variable speed secondary pumps, the IPC9511 will control the primary pumps and a separate controller (like Armstrong IPS4000 or Armstrong PSPC) is required for the secondary set}.
      2. The plant control system shall be supplied with all the hardware, software and programming required to control up to 5 air cooled chillers, up to 5 variable speed pumps (with options for single or dual pumps, if dedicated to the chillers), up to 5 chiller isolation valves (if the pumps are headered), 1 system by-pass valve to maintain minimum flow and up to 5 zone demand sensors (which can either be differential pressure or temperature sensors).
      3. The quantity of chillers, pumps, valves and demand sensors to be controlled shall be independently configurable (from 1 to the values in paragraph B) on-site at the graphic user interface by selection from pull down 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.
      4. 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.
      5. The plant control system 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 control system shall allow field adjustments of control parameters as described below.
      6. To be quoted as a separate additional price: A remote fault detection and diagnostics service shall be provided including quarterly performance reports and calibration for the first full year following commissioning.
      7. To be quoted as a separate additional price: Preventative maintenance and service shall be available directly from the manufacturer. This service should include inspection and review of key components, assessment of operation conditions, control system tuning, software upgrades as they are released, back-up and secure storage of parameters and annual training for the Building Operators.
   2. RELATED SECTIONS
      1. Section 15900 – HVAC instrumentation and controls / Section 25 5000 Integrated Automated Facility Controls
      2. Section 15620 - Chiller
      3. Section 15540 - HVAC packaged pumping system
      4. Section 13800 - BUILDING AUTOMATION AND CONTROL
      5. Section 15935 - Building Systems Controls
      6. Section 13801 - HVAC Control Systems
   3. STANDARDS REFERENCES AND QUALITY ASSURANCE
      1. The Chilled Water Plant Control System shall be assembled with components that conform to the latest edition of the following as applicable:
         1. ANSI – American National Standards Institute
         2. NEMA – National Electrical Manufacturers Association
         3. UL – Underwriters Laboratories
         4. CSA – Canadian Standards Association
         5. IEC - Degrees Of Protection Provided By Enclosures (IP Code)
         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 chilled water plant control system manufacturer must hold an ISO 9000 QA certification or approved equal.
   4. 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 panels.
         3. Install all life safety equipment as needed
         4. All field electrical connections to the unit. Hook up electrical supply needed by the plant control system (including field sensors). Connect with the BAS and confirm that BAS is ready to send/receive commands to the control system. 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
   5. SUBMITTALS
      1. Provide a complete Chilled Water Plant Control System 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
   6. 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.
   7. START-UP, COMMISSIONING, WARRANTY AND SERVICE
      1. The start-up and commissioning will be by a local Armstrong representative who is fully supported by Armstrong factory staff remotely.
      2. Warranty period: One (1) year parts and labour warranty (two years with warranty registration).
      3. To be quoted as a separate additional price: First Year - diagnostic services
         1. Following the date of commissioning completion, the vendor shall provide a \_\_\_ year (*1 year minimum*) of continuous diagnostic and health management service covering the central chilled water plant.
         2. The service shall include a web based self-serve interface.
         3. Included in the web interface shall be:
            1. Tracking of the project energy savings relative to the baseline:
            2. The baseline shall be calculated using measured equipment performance over a minimum of 90 days of continuous plant operation, or from building modelling software in accordance with ASHRAE Standard140 Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.
            3. Summaries via the web shall also include ongoing tracking of the performance relative to the predicted performance. The predicted performance will be based on daily measured building loads and external temperature and humidity. The assessment of the chilled water plant will include kW draws from each of the following: chiller(s), chilled water pump(s), condenser water pump(s) and cooling tower fan(s)
            4. Financial savings shall be calculated using the $/kWh rate provided by the customer. This shall include a provision for time of use “TOU” rates (if applicable) by applying the specific TOU rate to the savings per hour as measured and reported in the ongoing diagnostic service. Savings in energy shall be the difference between the actual chiller plant kW draw per hour compared to the baseline adjusted for the prevailing weather and building load to match that particular hour of measured consumption.
         4. The service shall include 4 (quarterly reports) that at a minimum include:
            1. Summary of plant efficiency profiled against operating loads
            2. Detailed chart of how the chilled water plant performed relative to the predicted performance.
            3. The predicted performance will be calculated as outlined above
            4. The report shall summarize of key findings regarding overall performance
            5. Recommendations to improve the efficiency of the overall chilled water plant based on the analysis
            6. The detailed quarterly report will be delivered electronically no later than 6 weeks at the end of the preceding quarter.
         5. Daily summaries shall be generated and provided in email or other electronic notification that summarize the actual measured efficiency of the chilled water plant relative to the predicted efficiency. The predicted efficiency shall be based on the outdoor weather conditions for the day (temperature and humidity in combination with the building load).
         6. An automatic email summary of notifications shall be customizable to fit the project specific instrumentation selected by the owner. Daily email notifications shall include options for the following:
            1. Chiller high evaporator approach (only available for Chillers with Serial communication)
            2. Chiller high condenser approach (only available for Chillers with Serial communication and Outside Air Temperature sensor is provided by others)
            3. Chiller excessive run hours
            4. Unstable chilled water supply
            5. Low delta t syndrome
            6. Chiller efficiency below expectations
            7. Pump rpm different than recommended
            8. Compressor excessive vibration (available if vibration sensors installed are provided by others)
            9. Pumps excessive vibration (available if vibration sensors installed are provided by others)
            10. High pump kW relative to chiller kW
2. PRODUCT
   1. MANUFACTURERS
      1. Acceptable Manufacturer: The air cooled chilled water plant control system shall be the IPC9511, by Armstrong Fluid Technology.
      2. Substitutions: Not permitted.
   2. HARDWARE
      1. CHILLED WATER PLANT CONTROL SYSTEM and Associated Equipment
         1. The chilled water plant control system shall be a stand-alone system capable of operating independently of the Building Management System (BMS), and at the same time capable of receiving remote instructions from the BMS.
         2. The plant automation shall be performed solely by the PLC and the PC shall not be required for plant operation, other than initial setup or configuration.
         3. The chilled water plant control system shall include a combination of PC-based and PLC controller.
         4. The chilled water plant control system shall have an internal circuit breaker and run on 100-240 Vac /1Ph/50-60Hz power supply.
            1. 10.4” back-lit touch screen LCD panel
            2. Operation temperature range: 0°C - 45°C (32°F-113°F) (must not be exposed to direct sunlight)
            3. Operation humidity range: 5% - 95%, non-condensing
            4. Power supply: AC 100-240V, 500 W
            5. *{select one of the following}* {UL mark, FCC compliant} or {CE mark, EN 61000-4-3 compliant}
         5. The control system shall have a key lockable {*select one of the following*} {NEMA 12} or {NEMA 4} or {IP54} or {IP55} rated cabinet. All operator interface control switches, indicators and displays shall be physically separated from any field terminations. Manual backup control switches and indicators must be protected from unauthorized operation by a key lockable door.
         6. The plant control system shall have Hand-Off-Automatic (H-O-A) control for each variable speed primary pump. The virtual H-O-A switch shall be accessible through the touch screen display, and in Hand mode, the control system shall allow the pump speed to be manually set and changed.
      2. SCREEN
         1. The chilled water plant control system shall include a back-lit touch screen color display operator interface of at least 10.4” 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 control system 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 control system shall be self-prompting. All messages shall be displayed in plain English, French, Spanish, Chinese and Portuguese. The operator interface shall have store in memory at least 50 faults and be able to recall them on the screen, on-screen help functions, and separate user screens for:
            1. Chiller configuration
            2. Pump configuration
            3. Differential pressure, flow, and temperature sensors’ setup
            4. Zone setups (including calibration of differential pressure/temperature sensor range)
            5. Alarm history and event review
            6. Display of zone status, chiller status, pump status and system status
            7. Factory default / commissioning setup data
            8. Best Efficiency Point speed setup
            9. PID control parameters setup
            10. BAS communication setup
            11. System schematic(s) showing chillers, pumps and valves operating parameters and sensors readings
      3. INSTRUMENTATION
         1. The chilled water plant control system shall provide the following remote mounted transmitters and sensors to be installed and wired back to the central plant control system by the installing contractor:
         2. Temperature sensors, pressure sensors and flow meter shall be installed by the contractor as indicated in the shop drawings to modulate the chilled water system.
         3. 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 control system 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.
         4. 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 control system 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.
         5. 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 control system. 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 insertable 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 chilled water plant control system software shall be preprogrammed to perform, but will not be limited to, the following:
            1. Manual or automatic control system
            2. Schedule start/stop
            3. Duty cycling
            4. Automatic lock-out of malfunctioning equipment
            5. Backup sequences of control for any sensor failure
            6. Automatic temperature control
            7. Pump control to satisfy zones demand
            8. Control sequences for dedicated and for headered pumps
            9. Control sequences for dual dedicated pumps with options for duty/duty, duty/standby and lead/lag operation
            10. Optimized sequencing of headered pumps
            11. Control sequences for Sensorless™ and zone sensors pump speed control options
            12. Zone setpoints reset based on most open load valve
            13. Optimized sequencing of chillers based on cooling demand
            14. Sequencing of chillers override to prevent exceeding their kW rating and FLA
            15. Supply temperature set point reset
            16. Load shedding / Demand limit
            17. Scanning and alarm processing
            18. Graphic screen reporting
            19. Trend Logging
         2. User Friendliness: The chilled water plant control system software shall be easy to operate. Operators shall be able to perform the following operations after one 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
            5. Log trend data
         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 control system shall be capable of accepting and processing appropriate signals (Differential Pressure, Temperature, or Flow) for the following dedicated terminal blocks:
            1. Up to 5 analog inputs (AI) for zone differential pressure, Temperature, signals 4-20 mA
            2. 2 AIs one for DP transmitter and one for flow sensor
            3. 5 digital inputs (DI), one per pump, differential pressure switch
            4. 1 DI for remote connection for start/stop
            5. 5 DIs for Isolation Valve Feedback
            6. 5 DOs for Isolation valve control
            7. 5 DIs for chiller alarm
            8. 5 DOs for chiller start/stop signal
            9. 5 AOs for chiller demand limit control
            10. 1 AO for chiller Chilled Water Setpoint
            11. 1 DI for alarm silencer,
            12. 3 DO for alarms: (a) controller communication alarm, (b) differential pressure transmitter alarm, (c) general system alarm
            13. 1 serial RS485 port and 1 Ethernet port for communication with the BMS,
            14. 1 serial port for communication with the VFDs,
            15. 1 terminal block for power supply 100-240 Vac/1 phase/50-60 Hz
         4. Trending and Reporting Capabilities: The control system shall provide a data-logging feature with 1 year of data at 5 minutes intervals and shall be capable of displaying the alarm history on its graphical touch screen display. The data must be easily downloadable monthly in a csv format file.
         5. The chilled water plant control system shall display live and trend data on demand. The control system shall provide graphic screens of system schematics.
         6. Communication Protocol: The chilled water plant control system shall be able to communicate with the Building Automation System over one or more of the following protocols: Modbus RTU, Modbus TCP, BACnet MS/TP, BACnet IP, Lonworks.
         7. The control system shall have preprogrammed Modbus communication points for Danfoss, Yaskawa and ABB drives and for Yorktalk 2, Yorktalk 3, SmartDT, McQuay AWG and McQuay Water-cooled chillers.
         8. The plant control system shall allow changes to the field the network address of equipment it communicates with (chillers, variable speed pumps, etc.) and its own address on the interface it communicates to the BAS. Network addresses cannot be hard coded.
         9. Remote Access: The chilled water plant control system shall include webserver functionality and be accessible through an internet TCP/IP internet address 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 setpoints, override equipment and navigate screens.
            2. View all available live and historic data
            3. Receive alarm messages, automatically processed and conveyed via the network and via email.
            4. Upgrade the plant control system software from the remote stations. Such remote upgrading shall not interrupt the plant operation and shall not require local intervention, (like locking equipment in manual).
            5. BAS/BMS and Internet connection shall be provided by others, but the controls contractor installing the plant control system is responsible of requesting it and coordinating with the IT contractor.
            6. Remote manual override by the BAS shall be possible for the following equipment settings:

Control System ON/OFF

Plant Mechanical mode/Stand-by mode

* + - 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. System fault alarms
         2. General alarm
         3. Pumps run feedback alarms
         4. Chiller alarms
         5. Pump alarm
         6. Drive fault alarms
         7. No flow alarm
         8. Zone/sensor alarm
         9. Drive communication alarm
         10. 4 potential free contacts shall be provided for general alarm, hooter/ buzzer, communication alarm and general sensor 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 chiller in case of chiller failure
         3. Auto omission of zone/sensor in case of any zone sensor
         4. Backup sequences in case of flow sensor failure, temperature sensor failure, and all zone sensors failure.
         5. Sequencing of chillers to prevent the flow through the running chillers to exceed their rated maximum (or fall below their minimum), or to exceed the power consumed by the running chillers to exceed their rated maximum
         6. Program distributed over several PLCs in such way that if those handling the most complex functions and remote communications fail, the lower level ones will keep the plant running with simpler logic.
         7. Indication of any Failure (or) malfunctioning in the touchscreen screen user interface, the remote access screens, in the BAS communication and via email to the operator.
         8. Pumps status confirmation with differential pressure switches
         9. Remote stop for emergency shutdown.
      3. Graphics shall be included for ease of system operation. Graphic screens shall include, but will not be limited to, the following:
         1. System schematic
         2. Chiller system schematic
         3. Building loop schematic
      4. Access Security: The control system shall have at least three levels of password security: one level for field adjustable parameters, a second for factory/commissioning setup parameters and a third for BAS communication commissioning.
      5. Sequence of Operation:
         1. All plant control system settings, including the number of chillers and 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 plant control system determines the most efficient combination of operating pumps, and pump operating speed based on the zone differential pressure, zone 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 control system shall respond to the most dissatisfied zone by increasing either, the number of operating pumps, or the pump speed.
         5. 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).
         6. The pump logic control system shall sequence the pumps based on a field adjustable interval of operating hours with a “bump-less” transfer algorithm. The control system incorporates an adjustable PID control loop and embedded logic to prevent hunting.
         7. The control system shall determine the optimum numbers of chillers to operate based on the plant load (thermal energy rejected) or to prevent the flow through the running chillers to exceed their rated maximum (or fall below their minimum), or to exceed the power consumed by the running chillers to exceed their rated maximum, or to prevent the supply temperature to exceed the setpoint by a field adjustable offset.
         8. For each chiller the control system has an adjustable field to enter its capacity. The plant load (in Tons and %) is displayed on the touch screen display and used to Stage On and Off the chillers, in conjunction with the other conditions explained in the previous paragraph.
         9. The control system shall rotate the Lead chiller on a field adjustable interval of operating hours. Should any chiller fail, the control system will trigger an alarm on the touch screen display and remove said chiller from the auto sequence and rotation.
         10. The control system shall be capable of interfacing with up to 5 isolation valves (used when the chillers are headered). A digital output opens and closes the valves, and a digital input provides open/close feedback.
         11. The control system modulates the bypass valve to maintain the minimum flow required by the operating chillers.
         12. Automatic operation mode: When the chilled plant control system is in automatic operation mode, the chiller plant is automatically started and all equipment is sequenced and modulated entirely automatically to meet the current cooling load with optimum operating efficiency.
         13. Manual operation mode (for commissioning): When the chilled plant control system is switched to the manual operation mode by the operator, there is no automatic operation or sequencing of any equipment and operation of chillers, chilled water distribution pumps, condenser water pumps, cooling towers and cooling tower fans continue at the same status when operation mode was switched to manual mode, until further changes by the operator. When operation mode is switched back to auto, the automatic operation mode is restarted.
      6. The chilled plant control system shall be capable of providing parallel 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
         4. Building return temperature sensor and/or
         5. Sensorless™ pump speed and parallel Sensorless™ pump control.

1. EXECUTION
   1. ELECTRICAL WIRING AND INSTALLATION
      1. The wiring for data communication between sensors, control systems 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 chilled water plant control system 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 chilled water plant control system manufacturer shall instruct the personnel of the facility in the operation of the control system. 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 control system 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, BACnet IP or Lonworks.

PLANT DESIGN SPECIFICATIONS

The chilled water plant shall be an air cooled variable speed plant with {*indicate the quantity*} \_\_ (*qty*) identical variable speed chillers and \_\_(*qty*) identical variable speed distribution pumps. The plant configuration shall provide {*select one of the following*} {headered 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. The bypass line 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*}