**­Design Envelope EVERCOOL**

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**Data Center Cooling Automation Solutions**

Typical Specifications

**Chiller Plant Automation for Data Centers**

1. GENERAL
   1. SCOPE – CHILLER PLANT Automation SYSTEM Project DESCRIPTION
      1. This specification is for the automation of a chiller plant, that has \_\_(qty) chillers in parallel. The plant has identical headered (or dedicated) cooling towers in parallel, with headered (or dedicated) arrangement of primary pumps and headered (or dedicated) arrangement of condenser pumps.
      2. The data center design is up to tier 4 per uptime institute requirements with (N+1, 2N, 2N+1, N) equipment configuration.
      3. The plant configuration is an all variable chiller plant that has variable speed chillers, variable flow (or speed) cooling towers, variable flow (or speed) primary pumps, and variable flow (or speed) condenser pumps
      4. The plant configuration has multiple independent distribution circuits and dual sets of instrumentation.
      5. The plant shall be capable of operating in water side economizer mode during cool ambient temperature periods below WBT of 42°F / 5 °C.
      6. The plant shall be capable of operating in hybrid mechanical and economizer mode
      7. The plant complies design standards for: ASHRAE 90.4, Uptime Institute Tier Certification, BCA Green Mark, …
      8. The chilled water plant provides chilled water on demand to the CRAH/C units in the data halls. Chilled water demand at each data hall is modulated by a variable flow control valve.
      9. The plant automation system shall be capable of operating chilled water thermal storage tanks to ensure the data halls chilled water demand is satisfied even during power transfer or outages {if applicable}
      10. The plant automation system shall ensure a fixed temperature of chilled water at 12°C is provided to the data halls and satisfies the maximum data hall delta T of 8°C. The plant automation system shall determine demand for chilled water through a combination of; data hall return temperatures, differential pressure across the data hall zone control valve(s), open position of the data hall zone control valves, or data hall delta T.
      11. Distribution and/or Primary pump speed shall be automatically adjusted by the plant automation system to satisfy the cooling requirements of the data halls.
      12. Staging on or off parallel equipment shall be automatically controlled by the plant automation system to satisfy the cooling requirement of the data halls, and in consideration of the ambient conditions.
      13. In the case of equipment failure, or equipment with degraded performance, the plant automation system shall automatically alter its plant operating sequence to remove those compromised pieces of equipment from duty status.
      14. Where intelligent pump technology is included in the plant, the flow reading from those pumps may be utilized to ensure best efficiency staging of parallel pumps.
      15. The plant automation system shall have a cybersecure outbound communications cellular network that will only transmit data in the outbound direction. That outbound data shall be provided to the automation system manufacturer for use in system analytics, plant performance analytics, and for system firmware upgrade purposes. The transmitted data shall comply with the local jurisdictional legal requirements for the confidentiality, ownership, security, and management of 3rd party data for the address of the install equipment
      16. The plant automation system shall be supplied with all the hardware, software and programming required to control up to 6 {Select one of the following} {air-cooled} {water-cooled} chillers, up to 6 chiller evaporator isolation valves, up to 6 chiller condenser isolation valves, {for water-cooled chillers} {up to 6 cooling towers fans with variable speed drives, up to 6 cooling tower inlet isolation valves, up to 6 cooling tower outlet isolation valves, up to 6 condenser pumps,} up to 6 variable speed primary pumps, 2 chilled water bypass valves each capable of maintaining total chiller minimum flow, {for water-cooled chillers} {2 condenser by-pass valves each capable of maintaining minimum entering condenser water temperature} and up to 4 pairs (total 8, including redundancy) of zone demand sensors (which can either be all differential pressure or all temperature sensors).
      17. The quantity and grouping of chillers, {for water-cooled chillers} {cooling towers,} 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 the data and graphics corresponding to the selected plant.
      18. Only the field sensors (temperature, flow, differential pressure, etc.) shall be supplied separately in the quantities required by the configuration in paragraph A, except as indicated in the Spares section.
      19. The plant automation 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 data center infrastructure management (DCIM) software or building automation system (BAS).
      20. {For water-cooled chillers} {The plant automation system shall include energy saving algorithms to optimize the operation of variable speed condenser water pumps and cooling towers with variable speed fans, which minimizes energy and water consumption.}
      21. To be quoted as a separate additional price: An annual service contract for a software-based energy saving, analytics and diagnostic module that provides enhanced feedforward control by creating a digital twin of the plant and each piece of equipment. This self-learning module shall continuously compare the real and predicted performance of the plant and each piece of equipment in order to improve the persistence of plant operation.
      22. A performance management service shall be provided including quarterly performance reports and recommendations for improved operation in the first calendar year following commissioning, and on an annual subscription basis for subsequent years.
      23. 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, plant automation 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 25 50 00 - Integrated Automation Facility Controls
      2. Section 23 64 00 – Package Water Chillers
      3. Section 23 20 00 - HVAC Piping and Pumps Plumbing Systems
      4. Section 23 09 00 – Instrumentation and Control for HVAC
      5. Section 23 65 00 – Cooling Towers
   3. STANDARDS REFERENCES AND QUALITY ASSURANCE
      1. The Plant automation 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-[2019] - American Society of Heating, Refrigeration and Air-Conditioning Engineers – Energy Efficient Design of New Buildings
         7. ASHRAE 90.4-[2019] - American Society of Heating, Refrigeration and Air-Conditioning Engineers – Energy Standard for Data Centers
         8. ASHRAE 100 - American Society of Heating, Refrigeration and Air-Conditioning Engineers – Energy Efficient Design of Existent Buildings
         9. *{*For water-cooled chillers*} {*The water-cooled chiller plant automation 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 automation system (including field sensors). Connect with the BAS and confirm that BAS is ready to send/receive commands to the plant automation system. Provide internet connection to the automation system.
         5. Field connect equipment including but not limited to; pressure/temperature sensors, flow meters and their associated wiring to the automation controller unit (a list of field installed equipment will be supplied, along with installation instructions), communications to plant equipment such as chillers, cooling towers, pumps, control valves and other details in the project drawings. 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 automation system by self, or with the supervision of manufacturer personnel, dependent on project requirement.
   5. SUBMITTALS
      1. Provide a complete plant automation 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 warranty (18 months with warranty registration).
      3. A performance management service shall be provided in the first calendar year following commissioning, which includes the following:
         1. Following the date of commissioning completion, the vendor shall provide a multi-year term performance management service proposal covering the chiller plant.
         2. The service shall include an online dashboard component and shall not require any additional hardware added to the plant controller, except as required for Internet connectivity.
         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 Standard 140 – 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 chiller plant will include kW draws from each of the following: chiller(s), chilled water pump(s), *{*for water-cooled chillers*} {*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 chiller 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 chiller 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 chiller 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 excessive run hours
            3. Unstable chilled water supply
            4. Low delta t syndrome
            5. Chiller efficiency below expectations
            6. Pump rpm different than recommended
            7. Compressor excessive vibration (available if vibration sensors installed are provided by others)
            8. Pumps excessive vibration (available if vibration sensors installed are provided by others)
            9. High pump kW relative to chiller kW

{For water-cooled chillers}

* + - * 1. {Chiller high condenser approach (only available for Chillers with Serial communication and Outside Air Temperature sensor is provided)
        2. Cooling tower low flow
        3. Cooling tower high water consumption (optional flow meter on cooling tower water make up must be provided by others)
        4. Cooling tower max sump level exceeded (optional level indicator must be provided by others)
        5. Cooling tower below minimum sump level
        6. Cooling tower high leaving water temperature
        7. Cooling tower trip on vibration (available if vibration sensors installed are provided by others)}

1. PRODUCT
   1. MANUFACTURERS
      1. Acceptable Manufacturer: The plant automation system shall be the Design Envelope EVERCOOL, by Armstrong Fluid Technology.
      2. Substitutions: Not permitted.
   2. HARDWARE
      1. PLANT AUTOMATION SYSTEM and Associated Equipment
         1. The plant automation system 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 plant automation 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 plant automation system shall be compliant with the requirements for a Tier 4 certification by Uptime Institute.
         4. The plant automation system shall have a key lockable {select one of the following} {NEMA 12} {IP54} 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 plant automation system shall have Hand-Off-Automatic (H-O-A) control for each chiller, pump {for water-cooled chillers} {and cooling tower}, and provide the option for a remote on/off signal from a single dry type relay or via BAS serial communication signal. These virtual H-O-A switches shall be accessible through the touch screen display, and in Hand mode, the plant automation system shall allow the pump speed {for water-cooled chillers} {and the cooling tower fan speed} to be manually set and changed.
         6. The plant automation system shall have redundancy on:
            1. Hot standby PLC
            2. Redundant networking capability between critical-components (PLC, I/O modules)
            3. Redundant Network switches
            4. N+1 Remote I/O Modules with Distributed I/O assignment
            5. Individual (N +1) serial communication trunks for each equipment set {select one of the following}{Chillers, Pumps, Fans}{Chillers, Pumps}
            6. Support for hardwired equipment control with serial supervisory communication OR serial control communication only
         7. The plant automation system shall include the following features;
            1. Hot-Standby PLC
            2. Multi-color 15” back-lit touchscreen for all necessary user interface functions. Keypad based interfaces, LCD readouts, and LED displays will not be accepted.
            3. VPN Router
            4. Internal circuit breakers
            5. Operation temperature range: 0°C – 40°C (32°F – 113°F) (must not be exposed to direct sunlight)
            6. Operation humidity range: (10% – 85%) non-condensing
            7. Ambient air temperature for storage: 0°C – 60°C (32°F – 140°F)
            8. Redundant power supply with dual incoming feed: AC 100 – 240V, 50/60Hz, 240 W
            9. {select one of the following} {UL mark, FCC compliant} {CE mark, EN 61000-4-3 compliant}
      2. SCREEN
         1. The plant automation system shall include a back-lit touchscreen color display operator interface of at least 15” 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. No data shall be lost during power supply interruptions.
         2. The plant automation system shall be self-prompting. All messages shall be displayed in plain English with the options of alternate languages. The operator interface shall have on-screen help functions, storage memory of at least 500 faults and be able to recall them on the screen, and separate user screens for:
            1. Real time display of the efficiencies of plant and individual components, and the overall plant heat balance calculation
            2. Overview of the hydronic circuit indicating piping configuration, quantity, mode and status of connected equipment (chillers, pumps, *{*for water-cooled chillers*} {*cooling towers,*}* valves), grouping of each chiller (if enabled), system flow, bypass valve % opening, plant efficiency, outdoor air temperature and humidity (if enabled), plant load (%), chilled water supply temperature setpoint and deviation from the control curve (sensorless mode) or from the active zone (with zone sensors)
            3. Detailed view of each connected piece of equipment:

Up to 6 chilled water pumps *{*for water-cooled chillers*} {*and up to 6 condenser water pumps*}* with mode, status, drive status, run hours, speed (%), hand speed (%) and power consumption

Up to 6 chillers with mode, status, demand limit, run hours, rated capacity, flow (min., max., design), power and temperatures

*{*For water-cooled chillers*} {*Up to 6 cooling towers with mode, status, fan speed (%), fan drive status, run hours, hand speed (%) and power consumption*}*

Chilled *{*for water-cooled chillers*} {*and condenser*}* water isolation and bypass valves with mode and status

* + - * 1. Overview of up to 4 zones with actual reading, setpoint, status and deviation of individual zone
        2. Current and historical data, including alarms and trends, which shall also be available to download in csv format
        3. Overview of the run hours of each connected chiller, pump {for water-cooled chillers} {and cooling tower}
        4. {for water-cooled chillers} {Status of auxiliary equipment for the condenser water circuit (if enabled)}
        5. Save and restore system parameters with options to/from local backup or via file upload/download
        6. Pump settings including speed control and sensorless setup data (including factory default setup data)
        7. Chiller settings including staging and operating parameters (including factory default setup data)
        8. {For water-cooled chillers} {Cooling tower settings including fan speed control and operation parameters (including factor default setup data)}
        9. Sensors settings including chilled {for water-cooled chillers} {and condenser} water circuit sensors (differential pressure, flow and temperature), chiller current/power sensors and up to 4 zone sensors (differential pressure or temperature) (including factory default setup data)
        10. Valves settings including operating parameters for isolation valves (chilled water, {for water-cooled chillers} {condenser water and cooling tower}) and PID parameters for cooling valves (ASHRAE 90.1 compliance) and bypass valves (chilled and condenser water) (including factory default setup data)
        11. Plant operating parameters and BAS communication setup (including factory default setup data)
        12. Settings for auxiliary equipment on condenser water circuit including make-up and blow-down water meter, water treatment, solid separator, and freeze protection
        13. Internal components diagnostic with current state and information
    1. INSTRUMENTATION
       1. The plant automation system shall provide the following remote mounted transmitters and sensors to be installed and wired back to the central plant automation 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 chiller 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. Each zone temperature sensor requires an identical pair for redundancy. 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 supply and return chilled water temperature sensors shall be identical, and each sensor shall also have an identical pair for redundancy. {For water-cooled chillers} {The supply and return condenser water temperature sensors shall be identical, and each sensor shall also have an identical pair for redundancy.} 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 plant automation 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. Each zone pressure sensor requires an identical pair for redundancy. 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 plant automation 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. Each flow sensor requires an identical pair for redundancy. 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 plant automation 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.
       6. Outside Air Temperature and Humidity Sensors shall include an integral sun shield and be located north side of the building. Each Outside Air Temperature and Humidity Sensor requires an identical pair for redundancy.
    2. SOFTWARE
       1. Capabilities: The plant automation 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. Rotation and delayed restart of malfunctioning equipment
          5. Management of redundant components in the control system
          6. Backup control sequences for the failure of any control system components, including PLCs and sensors
          7. Automatic temperature control
          8. Primary pumps control to satisfy zones demand
          9. Control sequences for dedicated and for headered pumps
          10. Optimized sequencing of the Chilled Water pumps
          11. Control sequences for Parallel Sensorless™ and zone sensors distribution pump speed control options
          12. Maintain minimum flow through the Chiller
          13. {For water-cooled chillers} {Constant flow Condenser pumps}
          14. Optimized and independent sequencing of chillers based on cooling demand
          15. Sequencing of chillers override to prevent exceeding their kW rating and FLA
          16. Supply temperature setpoint reset
          17. Scanning and alarm processing
          18. Graphic screen reporting
          19. Trend Logging
       2. User Friendliness: The plant automation system software shall be easy and intuitive 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. View and download logged trend data
          6. Receive, understand and respond to the notifications and recommendations of the diagnostics service
       3. Input/Output: A complete point schedule shall be provided detailing analogue and digital input and output points description, functions, types and any special requirements. The plant automation system shall be capable of accepting and processing appropriate signals, including differential pressure, temperature, flow, etc., for the following dedicated terminal blocks (Up to an additional 10% spare analogue and digital I/O’s to be provided for further project details or expansion):
          1. 8 analog inputs (AI), with 4 being redundant, for 4 zone differential pressure or zone temperature signals (4-20 mA)
          2. 6 AIs, one per chiller, for current or power sensors
          3. 8 AIs, with 4 being redundant, for supply and return temperature signals (chilled and condenser water)
          4. 4 AIs, with 2 being redundant, for chilled and condenser water dP transmitters
          5. 4 AIs, with 2 being redundant, for flow sensors (chilled and condenser water)
          6. 4 AIs, with 2 being redundant, for outdoor temperature and humidity sensors
          7. 4 AIs, with 2 being redundant, for bypass valves position feedback (chilled and condenser water)
          8. 6 analog outputs (AO), one per chiller, for demand limit control signals
          9. 4 AOs, with 2 being redundant, for bypass valves control signals (chilled and condenser water)
          10. 6 AO for chiller chilled water temperature setpoint
          11. 6 AO for chilled water pump speed reference
          12. 6 AO for condenser water pump speed reference
          13. 6 AO for cooling tower fan speed reference
          14. 12 DIs, 2 per chiller, for chilled water isolation valves open and close feedback
          15. 12 DIs, 2 per chiller, for condenser water isolation valves open and close feedback
          16. 12 DIs, 2 per cooling tower, for inlet isolation valves open and close feedback
          17. 12 DIs, 2 per cooling tower, for outlet isolation valves open and close feedback
          18. 6 digital inputs (DI), one per chilled water pump, for dP switch
          19. 6 digital inputs (DI), one per condenser pump, for dP switch
          20. 6 DIs, 1 per chiller, for chiller alarm
          21. 6 DIs, 1 per chiller, for status
          22. 6 DIs, 1 per chilled water pump, for run feedback
          23. 6 DIs, 1 per chilled water pump, for pump alarm
          24. 6 DIs, 1 per condenser water pump, for run feedback
          25. 6 DIs, 1 per condenser water pump, for pump alarm
          26. 6 DIs, 1 per cooling tower fan, for run feedback
          27. 6 DIs, 1 per cooling tower fan, for pump alarm
          28. 6 DIs, 1 per cooling tower recirculation pump, for run feedback
          29. 4 DIs, with 2 being redundant, for cooling tower high and low water level alarms
          30. 2 DI, with 1 being redundant, for remote connection for start/stop
          31. 2 DIs, with 1 being redundant, for emergency stop
          32. 2 DI, with 1 being redundant, for alarm silencer
          33. 2 DI, with 1 being redundant, for refrigerant leak
          34. 2 DI, with 1 being redundant, for secondary loop operating status
          35. 2 DI, with 1 being redundant, for make-up water meter pulse
          36. 2 DI, with 1 being redundant, for blow-down water meter pulse
          37. 2 DI, with 1 being redundant, for solid separator pump run feedback
          38. 2 DI, with 1 being redundant, for freeze protection run feedback
          39. 2 DI, with 1 being redundant, for water treatment system run feedback
          40. 12 digital outputs (DO), 2 per chiller, for chilled water isolation valves open and close control signal
          41. 12 digital outputs (DO), 2 per chiller, for condenser water isolation valves open and close control signal
          42. 12 DOs, 2 per cooling tower, for inlet and outlet isolation valves control signal
          43. 6 DOs, 1 per chiller, for start/stop control signal
          44. 6 DOs, 1 per chilled water pump, for start/stop control signal
          45. 6 DOs, 1 per condenser water pump, for start/stop control signal
          46. 6 DOs, 1 per cooling tower fan, for start/stop control signal
          47. 6 DOs, 1 per cooling tower recirculation pump, for start/stop control signal
          48. 2 DOs, with 1 being redundant, for alarm signal
          49. 2 DOs, with 1 being redundant, for emergency alarm signal
          50. 2 DOs, with 1 being redundant, for alarm horn (buzzer) signal
          51. 2 DO, with 1 being redundant, for enabling secondary loop operation
          52. 2 DO, with 1 being redundant, for enabling solid separator pump operation
          53. 2 DO, with 1 being redundant, for enabling freeze protection
          54. 2 DO, with 1 being redundant, for enabling water treatment system
          55. 6 Modbus serial port for communication with 1-chiller, 1-chilled water pump variable speed drive, 1-condenser water pump variable speed drive, 1-cooling tower fan variable speed drive each
          56. 1 serial port for communication with a building automation system (BAS)
          57. 2 terminal block for power supply 100-240 Vac/1 phase/50-60 Hz
       4. Trending and Reporting Capabilities: The plant automation system shall provide a data-logging feature with 3 year of data at 1 minutes intervals and shall be capable of displaying the alarm history on its graphical touch screen display. The data must be easily downloadable in a csv format file.
       5. The plant automation system shall display live and trend data on demand. The plant automation system shall provide graphic screens of system schematics.
       6. Communication Protocol: The plant automation system shall be able to communicate with the Data Center Infrastructure Management system or Building Automation System over one or more of the following protocols: Modbus RTU, Modbus TCP, BACnet MS/TP, or BACnet IP.
       7. The plant automation system shall have preprogrammed Modbus communication points for Armstrong, Danfoss, Yaskawa and ABB drives and preprogrammed Modbus and BACnet communication points for Smardt, York Talk2, York Talk3, McQuay Microtech II, McQuay Microtech III, and Trane RT/CG chillers.
       8. The plant automation system shall allow changes in the field to the network address, baud rate and parity it uses to communicate with the BAS. Network addresses cannot be hard coded.
       9. Remote Access: The plant automation 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.
          4. Upgrade the plant automation system software from the remote stations. Such remote upgrading shall not interrupt the plant operation and shall not require local intervention (such as locking equipment in manual operation).
          5. BAS and Internet connection shall be provided by others, but the controls contractor installing the plant automation 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:

Plant automation system 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 alarms
         2. Emergency stop alarm
         3. Refrigerant leak alarm
         4. Secondary loop not operating alarm (if secondary loop operation is enabled)
         5. Pumps no run feedback, VFD communication and VFD fault alarms
         6. Chillers no run feedback, no flow and communication alarms
         7. Sensors and transmitters (temperature, flow meter, pump head, dP, kW, outdoor air humidity and zone) alarms
         8. Isolation valves feedback alarms
         9. Bypass valves feedback and position alarms
         10. Cooling towers high and low water level, water consumption and cycles of concentration alarms
         11. Cooling tower fans no run feedback, VFD communication, VFD fault and all fans failed alarms
         12. Water treatment, solid separator and heat trace run feedback alarms (if enabled)
         13. 3 pairs of potential-free contacts, shall be provided for general alarm, buzzer, and emergency alarm
      2. Safety Features shall include but not limited to the following list:
         1. Hot standby-PLC
         2. Handling for when one of a pair of redundant sensors fails
         3. Backup sequences in the event both redundant sensors fail
         4. Auto omission of pump in case of pump failure
         5. Auto omission of chiller in case of chiller failure
         6. Auto omission of zone/sensor in case of any zone sensor failure
         7. 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
         8. Indication of any failure or malfunctioning in the touchscreen user interface, the remote access screens and in the BAS communication.
         9. Pumps status confirmation with differential pressure switches
         10. 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. Plant overview
         2. System schematic
         3. Plant efficiency
         4. Equipment status – of critical and redundant EVERCOOL components
      4. Access Security: The plant automation system shall have at least five levels of password security: Level zero (view only), Level one modify all parameters visible on the GUI + and set equipment in Hand (Site Operator) and Level two (save defaults) through the screen only. Level four and five access with a branded workbench and secured authorization only.
      5. Sequence of Operation:
         1. The plant automation system will monitor all redundant sensors and use the average of both. If one of the sensors goes out of range, it’s value will be ignored and the valid sensor reading will be used. If both sensors fail, fallback sequences below will be used.
         2. If emergency stop or refrigerant leak is detected, all chillers, pumps and cooling towers shall stop immediately, and the plant automation system shall be locked out of operation until alarm has been manually reset.
         3. The plant automation system shall determine the most energy efficient combination of operating primary pumps and pump operating speed by Parallel Sensorless™ sequencing with best efficiency point staging, or adjusts the pump speed to maintain the differential pressure or temperature of up to 4 zones at or above setpoint, while maintaining within equipment upper and lower flow limits and meeting system cooling load.
         4. The plant automation system shall continuously monitor all zone signals to determine an active control zone. Use of a multiplexer for multiple sensor inputs is not acceptable.
         5. The plant automation system shall automatically disable any zone differential pressure/temperature signals that are not within limits and alert the operator of a possible transmitter failure. If all the differential pressure/temperature sensors fail, the pump speed will default to a pre-defined percentage of full speed (factory default loaded as 95% of full speed).
         6. The plant automation system shall sequence the pumps based on a field adjustable interval of operating days with a “bump-less” transfer algorithm. The control system incorporates an adjustable PID control loop and embedded logic to prevent hunting, pump flow surge and motor overloading.
         7. The plant automation system shall determine the optimum numbers of pumps, chillers and cooling towers 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. Optional, ability to run redundant equipment for improved efficiency (all Duty) or assign as standby equipment.
         9. For each chiller the plant automation 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.
         10. The plant automation system shall rotate the lead chiller, lead pump and lead cooling tower on field adjustable intervals of operating days. Should any chiller, VFD/pump or cooling tower fail, the plant automation system will trigger the corresponding alarm and remove said equipment from the auto sequence and rotation. In place of the failed equipment, the next available chiller, pump or cooling tower shall be operated.
         11. The chilled water setpoint shall be determined by one of the three options: manual entry on the GUI or calculated based on the load, or provided by an external optimization module or the BAS.
         12. The plant automation system shall alert the operator if any of the return temperature sensors, supply temperature sensors or flow sensors failed, and maintain the number of chillers in operation (no stage on or off) until the alarm is cleared.
         13. Even if no chillers are running, as long as the plant automation system is enabled, one pump shall be operated to circulate water.
         14. The plant automation system shall be capable of interfacing with up to 6 chilled water isolation valves and up to 6 condenser water isolation valves. Digital outputs for opening and closing the valves, and digital inputs for open and close feedback.
         15. The plant automation system shall modulate the bypass valves to maintain the minimum chilled water flow and minimum entering condenser water temperature required by the operating chillers.
         16. The condenser pumps shall be sequenced with the chillers if they are variable speed and dedicated to the chillers, or constant speed.
         17. If variable speed, the condenser pump speed shall be capable of responding to load side demand with sensorless control within equipment upper and lower flow limits.
         18. If the condenser pumps are variable speed and headered to the chillers the plant automation system shall determine the most energy efficient combination of operating condenser pumps by Parallel Sensorless™ sequencing with best efficiency point staging.
         19. The plant automation system shall determine the optimized cooling tower fan speed, within a field adjustable range, based on heat rejection load.
         20. The plant automation system shall include energy saving algorithms to optimize the operation of the condenser water pumps and cooling towers.
         21. Automatic operation mode: the plant automation system shall include each of the chillers, pumps and cooling towers that are set in automatic operation mode in the sequence and modulate these equipment automatically to meet the current cooling load with optimum operating efficiency.
         22. Manual operation mode (for commissioning): When any chillers, pumps or cooling towers is switched to the manual operation mode by the operator, the operation of such equipment shall continue at the same status when operation mode was switched to manual mode until further changes by the operator. The plant automation system shall exclude equipment in manual mode from the automatic operation or sequencing. When operation mode is switched back to auto, the automatic operation mode shall be resumed.
      6. The plant automation system 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, 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 plant automation 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 plant automation system manufacturer shall instruct the personnel of the facility in the operation of the plant automation 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 setpoint 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 a variable speed plant with {*indicate the quantity*} \_\_ (*qty*) *{select one of the following} {*identical*} or {*non-identical*}* variable speed chillers, \_\_(*qty*) *{select one of the following} {*identical*} or {*non-identical*}* cooling towers with variable speed fans and one drive per tower, \_\_(*qty*) *{select one of the following} {*identical*} or {*non-identical*}* variable speed primary pumps and \_\_(*qty*) *{select one of the following} {*identical*} or {*non-identical*}* condenser pumps. The plant configuration shall provide on the chilled water side {*select one of the following*} {headered primary 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. On the condenser side, the plant configuration shall be {*select one of the following*} {headered cooling towers, headered condenser pumps and headered chillers} or {headered cooling towers and a dedicated {dual-arm} or {twin} or {single} pump to each chiller}. The plant shall supply a single distribution line from the supply header and receive a single return line from the loads. The plant shall supply a single pipe from the cooling 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 primary 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 a fan 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.