**System Envelope SE-A20 Air Cooled**

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**Chiller Plant Optimizer**

Typical Specifications

1. GENERAL
	1. SCOPE – AIR-COOLED CHILLER PLANT CONTROL SYSTEM DESCRIPTION
		1. This specification applies to the automation of an air-cooled chiller plant, which has 5 Mixed air-cooled chillers in parallel, 5 Headered Mixed variable speed primary pumps, supplying chilled water to 5 zones, whose demand is measured by a return temperature or differential pressure sensor. *{If the system has both variable speed primary and variable speed secondary pumps, the SE-A20 will control the primary pumps and a separate controller (such as Armstrong SE-F20) 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 chiller isolation valves, up to 5 variable speed primary pumps (with options for single or dual pumps, if dedicated to the chillers), 1 chilled water bypass valve to maintain total chiller minimum flow and up to 5 zone demand sensors (which can either be differential pressure or temperature sensors).
		3. The quantity and grouping 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 plant control system shall allow field adjustments of control parameters as described below.
		6. To be quoted as a separate additional price: a performance management service shall be provided including quarterly performance reports and recommendations for improved operation in the first calendar 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, plant 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 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
	3. STANDARDS REFERENCES AND QUALITY ASSURANCE
		1. The Water-Cooled Chiller 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-[2019] - 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 water-cooled chiller 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 plant 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 air-cooled chiller 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
	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. To be quoted as a separate additional price: First Year - Performance Management Services
			1. Following the date of commissioning completion, the vendor shall provide a multi-year term performance management service proposal covering the air-cooled 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 air-cooled chiller plant will include kW draws from each of the chiller(s) and chilled water pump(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 air-cooled 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 air-cooled 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 air-cooled 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 high condenser approach (only available for Chillers with Serial communication and Outside Air Temperature sensor is provided)
				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. Pumps excessive vibration (available if vibration sensors installed are provided by others)
				9. High pump kW relative to chiller kW
2. PRODUCT
	1. MANUFACTURERS
		1. Acceptable Manufacturer: The air-cooled chiller plant control system shall be the SE-A20, by Armstrong Fluid Technology.
		2. Substitutions: Not permitted.
	2. HARDWARE
		1. AIR-COOLED CHILLER PLANT CONTROL SYSTEM and Associated Equipment
			1. The air-cooled chiller plant control 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 air-cooled chiller 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 air-cooled chiller plant control system shall include:
				1. An internal circuit breaker
				2. Multi-color 10” back-lit touchscreen for all necessary user interface functions. Keypad based interfaces, LCD readouts, and LED displays will not be accepted.
				3. Operation temperature range: 0°C – 45°C (32°F – 113°F) (must not be exposed to direct sunlight)
				4. Operation humidity range: (10% – 85%) non-condensing
				5. Operating altitude up to 2000 m (6561 feet)
				6. Ambient air temperature for storage: 0°C – 60°C (32°F – 140°F)
				7. Power supply: AC 100 – 240V, 500 W
				8. UL mark, FCC compliant
			4. The plant control system shall have a key lockable UL Type 4/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 plant control system shall have Hand-Off-Automatic (H-O-A) control for each chiller, pump 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 control system shall allow the pump speed to be manually set and changed.
		2. SCREEN
			1. The air-cooled chiller plant control system shall include a back-lit touchscreen color display operator interface of at least 10” 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 control 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
				2. Dynamic overview of the hydronic circuit indicating piping configuration, quantity, mode and status of connected equipment (chillers, pumps, valves), grouping of each chiller (if enabled), system flow, bypass valve % opening, plant efficiency, outdoor air temperature (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 5 chilled water pumps with mode, status, drive status, run hours, speed (%), hand speed (%) and power consumption

Up to 5 chillers with mode, status, demand limit, run hours, rated capacity, flow (min., max., design), power and temperatures

Chilled water isolation and bypass valves with mode and status

* + - * 1. Overview of 5 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 and pump
				4. Save and restore system parameters with options to/from local backup or via file upload/download
				5. Setup and overview of weekly operating schedule for up to 3 chiller groups
				6. Pump settings including configuration, grouping (if chillers are mixed type and headered), speed control and sensorless setup data (including factory default setup data)
				7. Chiller settings including configuration, grouping (if chillers are mixed type), staging and operating parameters (including factory default setup data)
				8. Sensors settings including chilled water circuit sensors (differential pressure, flow and temperature), chiller current/power sensors and 5 zone sensors (differential pressure or temperature) (including factory default setup data)
				9. Valves settings including operating parameters for chilled water isolation valves and PID parameters for cooling valves (ASHRAE 90.1 compliance) and chilled water bypass valves (including factory default setup data)
				10. Plant operating parameters and BAS communication setup (including factory default setup data)
		1. INSTRUMENTATION
			1. The air-cooled chiller 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 air-cooled 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. 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 plant 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 plant 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 plant 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.
			6. Outside Air Temperature Sensors shall include an integral sun shield and be located north side of the building.
		2. SOFTWARE
			1. Capabilities: The air-cooled chiller 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. Primary pumps 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 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. Zone setpoints reset based on most open load valve
				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. Load shedding / Demand limit
				18. Scanning and alarm processing
				19. Graphic screen reporting
				20. Trend Logging
			2. User Friendliness: The air-cooled chiller plant control 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 control system shall be capable of accepting and processing appropriate signals, including differential pressure, temperature, flow, etc., for the following dedicated terminal blocks:
				1. 5 analog inputs (AI) for zone differential pressure or zone temperature signal (4-20 mA)
				2. 5 AIs, one per chiller, for current or power sensors
				3. 2 AIs for supply and return chilled water temperature signals
				4. 1 AI for chilled water dP transmitter
				5. 1 AI for chilled water flow sensor
				6. 1 AI for outdoor temperature sensor
				7. 1 AI for chilled water bypass valves position feedback
				8. 3 analog outputs (AO), one per chiller, for demand limit control signals
				9. 1 AO for chilled water bypass valves control signal
				10. 1 AO for chiller chilled water temperature setpoint
				11. 5 digital inputs (DI), 1 per chiller, for chilled water isolation valves open and close feedback
				12. 5 DIs, 1 per chiller, for chiller alarm
				13. 5 DIs, 1 per chilled water pump, for dP switch
				14. 1 DI for remote connection for start/stop
				15. 1 DI for emergency stop
				16. 1 DI for alarm silencer
				17. 1 DI for refrigerant leak
				18. 1 DI for secondary loop operating status
				19. 1 DI for chiller groups operating mode (if chillers are mixed type)
				20. 5 digital outputs (DO), 1 per chiller, for chilled water isolation valves open and close control signal
				21. 5 DOs, 1 per chiller, for start/stop control signal
				22. 3 DOs for alarms: (a) controller communication alarm, (b) sensor alarm, (c) general system alarm
				23. 1 DO for alarm horn (buzzer) signal
				24. 1 DO for enabling secondary loop operation
				25. 1 BACnet serial port and 1 Modbus serial port for communication with chillers
				26. 1 serial port for communication with a building automation system (BAS)
				27. 1 serial port for communication with chilled water pump variable speed drives
				28. 1 terminal block for power supply 100-240 Vac/1 phase/50-60 Hz
			4. Trending and Reporting Capabilities: The plant 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 air-cooled chiller plant control system shall display live and trend data on demand. The plant control system shall provide graphic screens of system schematics.
			6. Communication Protocol: The air-cooled chiller 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, or BACnet IP.
			7. The plant control 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 control 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 air-cooled chiller 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.
				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 (such as locking equipment in manual operation).
				5. BAS 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:

Plant Control 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 valve feedback alarm
				9. Bypass valve feedback and position alarms
				10. 4 potential free contacts shall be provided for general alarm, 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 failure
				4. Backup sequences in case of pressure or 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. Indication of any failure or malfunctioning in the touchscreen user interface, the remote access screens and in the BAS communication.
				7. Pumps status confirmation with differential pressure switches
				8. 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
			4. Access Security: The plant control 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. All plant control system settings, including the number of chillers and pumps, as well as how they are connected (headered or dedicated) shall be able to modify at the graphic user interface (GUI) after entering the appropriate password.
				2. If emergency stop or refrigerant leak is detected, all chillers and pumps shall stop immediately, and the plant control system shall be locked out of operation until alarm has been manually reset.
				3. The plant control 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 5 zones at or above setpoint, while maintaining within equipment upper and lower flow limits and meeting system cooling load.
				4. The plant 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.
				5. The plant control 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 system found all differential pressure/temperature sensors failure in the building, the pump speed will default to a pre-defined percentage of full speed (factory default loaded as 95% of full speed).
				6. The plant control 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. To meet ASHRAE 90.1 requirement, the plant control system shall obtain the position of the most open cooling valve from the BAS and maintain this valve position at 95% by a PID loop.
				8. The plant control system shall determine the optimum numbers of pumps and 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.
				9. For each chiller the plant 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.
				10. The plant control system shall rotate the lead chiller and lead pump on field adjustable intervals of operating days. Should any chiller or VFD/pump fail, the plant control 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 or pump shall be operated.
				11. The chilled water setpoint shall be determined by one of the three options: manual entry on the GUI, calculated based on the outdoor air temperature, or provided by an external optimization module or the BAS.
				12. The plant control 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 control system is enabled, one pump shall be operated to circulate water.
				14. The plant control system shall be capable of interfacing with up to 5 chilled water isolation valves. A digital output opens and closes the valves, and a digital input provides open/close feedback.
				15. The plant control system shall modulate the bypass valve to maintain the minimum chilled water flow required by the operating chillers.
				16. The plant control system shall be capable of operating up to 5 chillers of 3 different sizes or types with the following conditions:

If the chilled water pumps are in headered configuration, there can be 3 sizes or 3 types of chillers; up to 3 chiller groups can be formed with the condition that only identical chillers (i.e. make & model, size, minimum flow, etc.) can be grouped together.

If the chilled water pumps are in dedicated configuration, there can be up to 3 sizes or 3 types of chillers; up to 3 chiller groups can be formed

* + - * 1. In headered configuration, the plant control system shall allow up to 3 pump groups to be formed if there are 3 chiller groups available, with the condition that only identical pumps (i.e. same make & model, flow, head, etc.) shall be grouped together. Each pump group is associated with the corresponding chiller group, and only pumps in the active pump group is enabled and staged. 1 pump in each pump group shall be allowed as stand-by.
				2. To operate different sizes/types of chillers, the plant control system shall determine which group of chillers to operate based on either a digital input or a scheduler configurable via the GUI. Only chillers in the active chiller group and its associated pumps group, shall be enabled and staged.
				3. Automatic operation mode: the plant control system shall include each of the chillers and pumps 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.
				4. Manual operation mode (for commissioning): When any chillers or pumps 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 control 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.
			1. The air-cooled chiller plant control 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 air-cooled chiller 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 air-cooled chiller plant control system manufacturer shall instruct the personnel of the facility in the operation of the plant 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 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 air-cooled variable speed plant with 5 Mixed variable speed chillers and 5 Mixed variable speed primary pumps. The plant configuration shall provide on the chilled water side headered primary pumps and headered chiller a dedicated 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(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*}