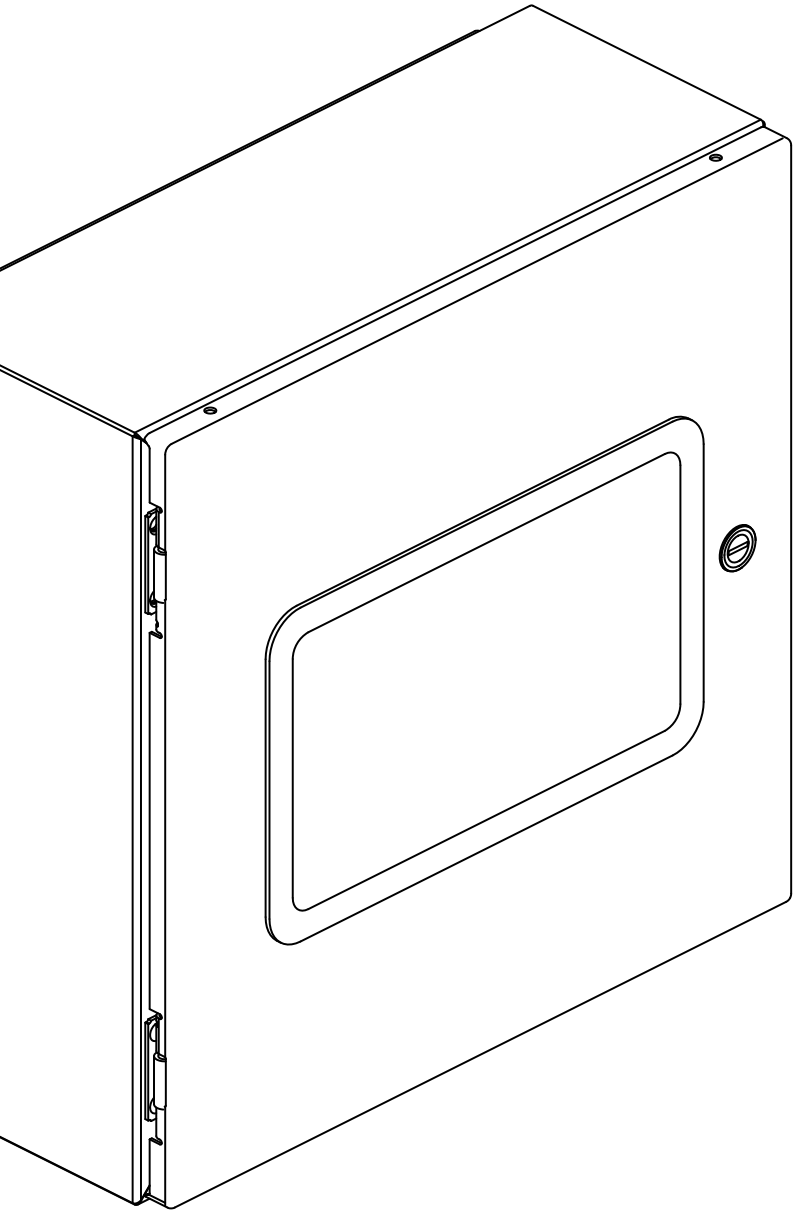
ARMSTRONG



OPTI-VISOR™ ultra-efficient chiller plant automation

Typical specification

File No: 90.893
Date: FEBRUARY 9, 2015
Supersedes: 90.893
Date: APRIL 20, 2012

CONTENTS

1.0 CHILLED WATER PLANT

1.1 GENERAL SYSTEM REQUIREMENTS

- The chilled water plant shall be a water-cooled all-variable speed plant with variable flow and variable speed chillers, variable flow cooling towers (variable speed fans and pumps) and variable speed distribution pumps.
- The application shall be comfort cooling.
- The system design shall be either variable flow primary system or variable flow primary/variable flow secondary system.
- Chilled water primary pumps, [secondary pumps] and condenser pumps could be in parallel, dedicated or duty/standby operation.
- All pieces of equipment in each set (cooling towers, condenser pumps, chillers and chilled water pumps) shall be identical.
- The chiller plant shall involve up to six chillers, up to six cooling towers, up to six variable chilled water primary pumps, [as many as required variable chilled water secondary pumps] and up to six variable condenser pumps.

1.2 PLANT INFORMATION REQUIRED TO CONFIGURE THE OPTIMIZER

The following information shall be made available by the plant owner or its representatives, for predicted performance analysis and to configure the optimizer for the plant:

- Plant geographical location and design day load.
- Load profile (expected hours of operation per year at different loads ranges).
- Plant piping and instrumentation diagram.
- Chiller nameplate and design data, including capacity, number of compressors, design kW draw, [design, maximum and minimum] condenser and chilled water flows, minimum load and tested performance at design load and at least four part load points, specifying flows and water temperatures for each point.
- Tower nameplate and design data, including capacity, design kW draw, design and minimum fan speeds, [design, maximum and minimum] water flows, and design approach.
- Pumps nameplate and design data, including design flow, head kW draw, and the flow/head curve at maximum speed.

2.0 CHILLED WATER PLANT CONTROL SYSTEM

The chilled water plant control system shall be an all-variable speed plant automation system that executes the following functions:

- Sequences and rotates the chillers.
- Adjusts the chilled water supply temperature set point.
- Provides variable speed control instruction to the cooling tower pumps and fans.
- Controls the variable primary [and/or secondary] chilled water distribution pumps in response to process variable from the load (DP signal sensors, flow meters, valve positions and/or kW meters).
- Provides instruction to the isolation valves and modulates the supply and condenser bypass valves, if present.
- Provide system alarms and warnings.
- Is capable of receiving optimization instructions from an external optimization controller utilizing Hartman LOOP™ demand based relation control through a local serial communications bus (required points listed below).

The chilled water plant control system may be part of the building automation system, or a stand alone plant automation controller (which may communicate plant operation status and alarm data to a building automation system and receive commands and parameters through a local serial communications bus).

The chilled water plant control system shall receive the operating instructions from the optimizer, and is responsible to operate the plant equipment at those optimized equipment settings.

The chilled water plant control system is at all times (even if communication with the optimizer panel fails) responsible for the safe sequencing, operation, and control of the plant equipment in compliance with all the plant equipment operating constraints, and shall, whenever possible, respond to equipment alarms by sequencing on additional standby equipment to maintain appropriate cooling to the building.

The plant control system shall be capable of reading and processing appropriate signals for at least the following data points, either through serial communication or hardwired, and directly or from associated panels:

- Analog inputs for primary flow, all plant elements consumed kW, and supply and return temperature sensors (chilled and condenser water).
- Analog inputs for zone differential pressure (DP), valve positions and/or zone BTU meters that determine the flow demand to be satisfied by the supply pumps.
- Digital inputs for status of condenser, primary [and secondary] pumps.
- Digital inputs for status of towers fans and chillers.
- Digital inputs for status of isolation valves.
- Digital inputs for alarm signals from chillers, pumps and fans.
- Digital outputs for condenser, primary [and secondary] pumps start/stop signals.
- Digital outputs for tower fans and chillers start/stop signals.
- Digital outputs for isolation valves open/close signals.
- Analog outputs for chiller's water supply temperature set point adjustment.
- Analog outputs for supply and condenser by-pass valves, if present.
- Serial data communications from the chilled water plant optimizer.

The plant control system shall receive the following control signals from the optimizer panel through a local digital serial communications bus:

- Requested optimal number of chillers to operate.
- Requested optimal number of cooling towers/fans to operate.
- Requested optimal number of condenser water pumps to operate.
- Requested optimal condenser water pump speed.
- Requested optimal tower fan speed.
- Requested optimal chilled water supply temperature set-point.
- **Warning** – Plant control system not following optimization advice.
- Communication watchdog signal.

The plant control system shall send the following control signals to the optimizer panel through the serial communications bus:

- Primary water flow.
- Chilled water supply temperature.
- Chilled water return temperature.
- Condenser water entering temperature.
- Condenser water leaving temperature.
- Running status each tower fan, condenser pump, chiller and primary pump.
- Speed of each fan, condenser and primary pump.
- Alarm status each tower fan, condenser pump, chiller and primary pump (availability to run).
- kW draw of each tower fan, condenser pump, chiller and primary pump (or, at least, one of each set).
- Communication watchdog signal.
- "Optimizer enable"

2.1 SENSORS AND SWITCHES

- The temperature sensors measuring the supply and return temperatures for each loop (condenser and chilled water); the two probes shall be matched pair. The accuracy of the temperature sensors shall be the lesser of 0.25% of span or 1F. Sensors shall be mounted such that the reading is not affected by stratification, the effects of radiation from heating elements are minimized, and rapid response to changing temperature is achieved.
- The accuracy of the differential pressure sensors shall be 0.25% of span.
- Pressure switches shall have adjustable ranges and adjustable differentials to suit the application. Pressure switches shall be sensitive enough to ensure correct monitoring. Switches shall be mounted such that they are not affected by turbulence or eddies.
- Flow sensors shall have an accuracy of 2% of reading or better. Magnetic or ultrasonic types are preferred. Sensors shall be mounted such that the reading is not affected by stratification.

2.2 ELECTRICAL WIRING AND INSTALLATION

- All wiring for communication between sensors, controllers (including the optimizer panel) and valve actuators 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.

2.3 CONTROL CONTRACTOR RESPONSIBILITIES

The controls contractor is responsible for the following:

- Site audit and assessment of communications requirements between the plant control system, the plant equipment, and the optimizer.
- Furnish and site installation of any necessary variable frequency drives (VFDs) on existing pumps or fans to make the chiller plant an all-variable speed plant.
- Furnish and installation of any necessary instrumentation and control valves to provide the necessary control signal for the proper operation of the all-variable speed plant.
- Furnish and install the optimizer.
- Make the necessary control sequence changes to the existing plant control system to enable taking instructions from the plant optimizer.
- Modify the existing plant control system to include the necessary data-points for instructions from the optimizer.
- The supply and installation of all necessary ancillary hardware required to enable the all-variable speed plant operation with the optimizer.
- Commissioning of the plant control system and optimizer with the support of the optimizer manufacturers personnel.
- Installation of the intranet and Internet access.

3.0 CHILLER PLANT CONTROL SYSTEM OPTIMIZER

The following specification details the minimum requirement for a complete factory assembled plant control optimizer.

The optimizer shall be a device implementing the Hartman LOOP™ control algorithm which shall communicate the calculated best operation point to the chiller plant control through a local digital serial communications bus.

3.1 RELATED SECTIONS

- Chiller specifications (Section 15620)
- Cooling tower specifications (Section 15645)
- HVAC packaged pumping system (Section 15540)
- Plant design specifications (Section .....)
- Building automation system (Section .....)

3.2 STANDARDS AND REFERENCES

- ANSI – American National Standards Institute
- NEMA – National Electrical Manufacturers Association
- UL – Underwriters Laboratories
- CSA – Canadian Standards Association

3.3 ACCEPTABLE MANUFACTURERS

The chilled water plant optimizer shall be the OPTI-VISOR™ from Armstrong.

3.4 HARDWARE

3.4.1 GENERAL FEATURES

The optimizer enclosure shall be a key lockable NEMA 1 rated cabinet with an externally accessible touchscreen, an Ethernet port and knock off accesses for power and serial bus communications.

The optimizer user interface shall be a combination of a 7" color touchscreen, intranet communications based virtual control dashboard, a web site virtual control dashboard, and a web site report site.

The optimizer shall have an internal circuit breaker and run on 100 to 230V AC/1 phase/50 or 60hz power supply. The optimizer shall have a battery or capacitor that keeps the memory in the panel alive long enough to get the system through temporary power failures.

The optimizer shall operate from factory developed software, firmware and project specific programming on a commercial grade PLC. The optimizer shall be capable of remote software/firmware upgrades while the system is still operating. The optimizer system shall provide some means of backing up the entire database to disk, either in parts or all at once.

The optimizer shall be listed by and bear the label of Underwriter's Laboratory, Inc. (UL) and of Canadian Standards Association (CSA).

3.4.2 SCREEN

The optimizer shall have a large touch screen color display operator interface of at least 7" with on-screen menu-driven operator interface and active element schematic displays that generate sub-menus for status reports, data and setup menu options. Keypad based interfaces, LCD readouts and LED displays shall not be accepted.

Screen minimum requirements are:

- 7" 800×480 TFT high brightness WVGA panel.
- Resistive type touch screen.
- NEMA 4/12 certified front bezel.
- Operation temperature range: 0°C – 40°C (32°F – 104°F).
- Operation humidity range: 5% – 95%, non-condensing.
- Power supply: AC 100 – 230 V, 100 W.
- CE, FCC compliant, UL, CSA, or ETL marked.

3.5 SOFTWARE

3.5.1 CAPABILITIES

The optimizer software shall perform, but will not be limited to, the following:

- Hartman LOOP™ based recommendations.
- Optimum equipment sequencing.
- Optimum supply temperature.
- Optimum equipment speed.
- Scanning and alarm processing.
- Graphic screen reporting (local, remote).
- Trend logging.
- Totalization.
- Serial communication to plant controller.
- Act as a web server for remote access.

3.5.2 INPUT/OUTPUT

The optimizer panel shall receive the following control signals from the plant control system through a serial communications bus:

- Primary water flow.
- Chilled water supply temperature.
- Chilled water return temperature.
- Condenser water entering temperature.
- Condenser water leaving temperature.
- Running status (on/off) of each tower fan, condenser pump, chiller and primary pump.
- Alarm status (availability to run) of each tower fan, condenser pump, chiller and primary pump.
- Speed of each fan, condenser and primary pump.
- kW draw of each tower fan, condenser pump, chiller and primary pump (or, at least, one of each set).
- Communication watchdog signal.
- "Optimizer enable"

The optimizer panel shall send the following control signals to the plant control system through the serial communications bus:

- Requested optimal number of chillers to operate.
- Requested optimal number of cooling towers/fans to operate.
- Requested optimal number of condenser water pumps to operate.
- Requested optimal condenser water pump speed.
- Requested optimal tower fan speed.
- Requested optimal chilled water supply temperature set-point.
- **Warning** – Plant control system not following optimization advice.
- Communication watchdog signal.

3.5.3 TRENDING AND REPORTING CAPABILITIES

The optimizer system shall have alarm and event logging capability and shall store at least three months of all points exchanged with the plant controller sampled every five minutes, in non-volatile memory and the data must be easily retrievable through its intranet access. The optimizer system shall display live and trend data on demand. The controller shall allow the operator to select points, group of points and mechanical systems through a menu. The controller shall provide graphic screens of system schematics.

3.5.4 TOTALIZATION

The optimizer shall calculate, store and show the accumulated equipment run time.

3.5.5 COMMUNICATION PROTOCOL

The optimizer shall be able to communicate with the chilled water plant in at least the following protocols: Modbus RTU, Modbus TCP, BACnet MSTP, BACnet IP, MetaSys N2, Lonworks and TREND.

3.5.6 INTRANET AND WEB ACCESS

The optimizer shall provide an Ethernet TCP/IP internet address with both read/write functionality. This access shall allow the relevant staff to locally or remotely:

- Using a standard Internet browser, view a set of screens showing live and historical data, including plant energy efficiency, opitimizer recommendations, sensor readings, equipment running, speed and alarm status, plant controller compliance status and communication status.
- Receive alarm messages, automatically via email.
- Troubleshoot, configure and download program updates remotely.

3.5.7 ALARMS

Whenever abnormal conditions arise, alarms shall be generated and the alarm messages shall be displayed in clear textual form on the screen, until it is acknowledged. Critical alarms shall also be sent via email to the operator.

3.5.8 GRAPHICS

Graphics shall be included for ease of system operation. Graphic screens shall include, but will not be limited to, the following:

- Performance, plant controller compliance status and communication status.
- Chiller system status schematic
- Alarms
- Trends and run times

3.5.9 ACCESS SECURITY

The optimizer shall have three levels of password security: one level for viewing only, a second for field adjustable parameters, and a third for factory/commissioning setup parameters and software upgrades.

3.5.10 SEQUENCE OF OPERATION

The optimizer control system shall utilize demand based control for the tower fan and pump speed and shall provide the chiller with a chilled water supply temperature set-point for the chiller to govern its operation. The chillers shall be sequenced/staged, both on and off in a manner to maintain their operation as close as possible to the natural curve. The cooling tower fan speed and pump speed settings shall vary in accordance to the Equal Marginal Performance principle. The 'natural curve', 'demand based control' and 'equal marginal performance principle' methodologies described above are to be in accordance with the Hartman LOOP™ operating principles of an all-variable speed chiller plant.

Alternate plant control sequences that can be proven to provide a net plant efficiency level of 0.55 kW/ton or better will be considered with a written proposal with calculations submitted at the time of quotation. Net plant efficiency level is calculated as the average annual kW/ton for the annual energy input to the chiller, cooling tower and distribution pumps, divided by the annual tons delivered to the system.

3.6 SUBMITTALS AND OPERATION MANUALS

3.6.1 SUBMITTALS MINIMUM CONTENT

- Description of system operation.
- Electrical power and control wiring diagram.
- Control layout drawing with sequence of operations.

- Energy analysis of the predicted plant's annual average energy efficiency.
- Energy analysis of the predicted plant efficiency in kW/ton at a combination of cooling loads and weather conditions: 0 to 100% load in 5% increments, and 50°F to 90°F outdoor wet bulb temperature in 5°F increments.
- The work scope requirements of site contractor, site operating personnel, and the manufacturers service and startup team.

3.6.2 OPERATION AND MAINTENANCE MANUALS MINIMUM CONTENT

- System summary sheet
- Description of system operation, with equipment and control sequence of operation.
- Electrical power and control wiring diagrams.
- Installation and maintenance manuals from equipment manufacturers.
- Operator instructions including procedures for downloading data, web access to report and system operation interfaces and interpretation of alarms.
- Submittals and operation and maintenance manuals shall be assembled in a neat and orderly manner and bound in booklet form they will also include a front page that identifies the job particulars followed by a table of contents.

3.7 EXECUTION

This section shall conform to the general provisions, basic materials and methods section. The equipment installed in this section shall conform to all other relevant sections of the mechanical and electrical sections of this specification.

3.7.1 QUALITY ASSURANCE

The optimizer manufacturer must hold an ISO 9000 QA certification or approved equal. The optimizer panel shall be manufactured and labeled in accordance with UL508A (CSA C22.2 #14 for use in Canada). Supplying UL recognized individual components is not sufficient. The assembled control enclosure, as a whole, must be inspected for proper wiring methods, fusing, etc. and must be labeled as conforming to UL508A. Inspection and labeling shall be supervised by UL or OSHA approved Nationally Recognized Test Lab (NRTL). Lack of an NRTL certified UL508A wiring methods inspection and labeling will be grounds for control enclosure rejection.

Documented test procedures are to be available to the customer upon request. The optimizer panel must be tested in the factory to confirm the performance prior to shipping. Documented test results shall be available upon customer request. The controller shall be factory tested with all sequences and alarms simulated. Factory testing equipment shall be calibrated as outlined in the quality assurance manual and be made available for customer inspection upon request.

The controller manufacturer shall have a quality assurance manual available for the customer upon request.

3.7.2 TRAINING

The chilled water plant control system manufacturer and optimizer manufacturer shall instruct the personnel of the facility in the operation of the controller. Drawings, operation and maintenance manuals are to be provided to the customer.

3.7.3 SITE TESTING

Upon completion of all system startup and checkout procedures and while the mechanical systems is monitoring and controlling 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. The test must meet the particular building's design requirements to be considered passed and acceptable. Any failures shall require the test to be restarted.

3.7.4 CALIBRATION, COMMISSIONING, AND PERFORMANCE REPORTING

The chilled water plant optimizer panel shall be commissioned and fully operational after delivery to the site at an agreed date. Commissioning procedure shall conform to the mechanical services section of these specifications.

The calibration and commissioning procedure shall consist of verifying communication, sequences of operation, operation within limits, and expected performance. All commissioning information shall be documented on commissioning data sheets which shall be submitted to the facility personnel for approval prior to testing. The facility personnel shall be notified of the commissioning schedule so they may witness the procedure.

4.0 ANNEX

The optional specifications below are to further improve the plant equipment which would result in even better plant efficiency when OPTI-VISOR™ is installed.

4.1 CHILLER SPECIFICATIONS (SECTION 15620)

The chillers shall have variable speed compressors with variable frequency drives (VFDs) and shall be capable of speed turndown to provide less than 41% of full load capacity by way of compressor speed control 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 a pre-set cooling tower supply temperature that may range from 60°F to 90°F.

The chillers must comply with the ASHRAE 90.1 standard for part load efficiency rating according to ARI standards.

The chiller shall be able to accept external demand limiting instructions from the chiller plant control system.

The chiller controller must be capable of communicating through the following protocols: Lonworks, Modbus or BACnet.

4.2 COOLING TOWER SPECIFICATIONS (SECTION 15645)

The cooling tower shall include fans that will operate safely on variable frequency drive power supplies and all resonant operating frequencies shall be skipped at the drive supply frequency, rotational speed and 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.

4.3 PLANT DESIGN SPECIFICATIONS (SECTION 15...)

The chilled water plant shall be an all-variable speed plant with variable speed chillers, distribution pumps, cooling tower pumps and cooling tower fans. The plant configuration shall provide either a dedicated pump/pump set to each chiller or fully headered pumps and either a dedicated cooling tower/tower set to each chiller or fully headered towers.

4.4 CHILLED WATER SYSTEM PUMPS SPECIFICATIONS (SECTION 15...)

The chilled water system distribution pumps and condenser water pumps shall be variable speed pumps. The chiller plant shall be specifically designed for up to five variable speed chilled water distribution pumps and up to five variable speed condenser pumps.

TORONTO
+1 416 755 2291

BUFFALO
+1 716 693 8813

BIRMINGHAM
+44 (0) 8444 145 145

MANCHESTER
+44 (0) 8444 145 145

BANGALORE
+91 (0) 80 4906 3555

SHANGHAI
+86 21 3756 6696