

**SECTION 23 6416**  
**CENTRIFUGAL WATER CHILLERS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Chiller package.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Chilled water connections.
- E. Condenser water connections.
- F. Variable speed drives.
- G. Starters.
- H. Electrical power connections.

**1.02 RELATED REQUIREMENTS**

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete housekeeping pads.
- B. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- C. Section 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- D. Section 23 0553 - Identification for HVAC Piping and Equipment.
- E. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- F. Section 23 0800 - Commissioning of HVAC.
- G. Section 23 0923 - Direct-Digital Control System for HVAC.
- H. Section 23 2113 - Hydronic Piping.
- I. Section 23 2114 - Hydronic Specialties.
- J. Section 23 2123 - Hydronic Pumps.
- K. Section 23 2500 - HVAC Water Treatment.
- L. Section 23 6513 - Forced-Draft Cooling Towers.

**1.03 REFERENCE STANDARDS**

- A. AHRI 550/590 - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle; 2011.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- C. ASHRAE Std 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Addenda.
- D. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.
- E. IEEE 519 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems; 2014.
- F. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- C. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.

- D. Manufacturer's Certificate: Certify that components of package not furnished by manufacturer have been selected in accordance with manufacturer's requirements.
- E. Test Reports: Indicate energy input versus cooling load output from 0 to 100 percent of full load at specified and minimum condenser water temperature.
- F. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.
- G. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories. Include trouble- shooting guide.
- H. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

#### **1.05 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

#### **1.07 WARRANTY**

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide a two year warranty to include coverage for compressor including materials only.
- C. Variable Speed Drives: Provide manufacturer warranty for period of twelve months from date of installation or eighteen months from date of shipment (whichever comes first). Warranty to include parts, labor, travel costs, and living expenses incurred by manufacturer to provide factory-authorized on-site services.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Carrier, a part of UTC Building and Industrial Systems, a unit of United Technologies Corp; \_\_\_\_\_: www.carrier.com.
- B. Trane, a brand of Ingersoll Rand; \_\_\_\_\_: www.trane.com.
- C. York International Corporation/Johnson Controls, Inc; \_\_\_\_\_: www.york.com.
- D. Substitutions: See Section 01 6000 - Product Requirements.
  - 1. The chilled water system has been designed based on specific capacities and characteristics of equipment specified in this section and other sections.
  - 2. When substitution of a different manufacturer or model number is desired, submit sufficient information to demonstrate to Architect that the substitute will have the same or better performance as that specified AND that the related equipment in the system will perform acceptably with the substitute.
  - 3. If the related equipment must be modified to perform acceptably with the substitute, the entity proposing the substitution is responsible for all additional costs due to re-design and provision of different related equipment.

#### **2.02 CHILLER APPLICATIONS**

- A. Chiller CH-1: Water-cooled, two-stage, single compressor.
  - 1. Rating: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than prescribed by ASHRAE Std 90.1.
  - 2. Evaporator:
    - a. Working Pressure: 150 psi.
    - b. Fouling Factor: \_\_\_\_\_.
    - c. Flow: \_\_\_\_ gpm.

- d. Entering Temperature: \_\_\_\_ degrees F.
  - e. Leaving Temperature: \_\_\_\_ degrees F.
  - f. Pressure Drop: \_\_\_\_ feet.
  - g. Glycol Type: \_\_\_\_\_.
  - h. Glycol Concentration: \_\_\_\_\_ percent.
3. Condenser Water:
- a. Working Pressure: 150 psi.
  - b. Fouling Factor: \_\_\_\_\_.
  - c. Flow: \_\_\_\_ gpm.
  - d. Entering Temperature: \_\_\_\_ degrees F.

### 2.03 CHILLERS

- A. Chillers: Factory assembled and tested, packaged, water cooled, chillers consisting of centrifugal compressors, compressor motor, condenser, evaporator, refrigeration accessories, instrument and control panel including gages and indicating lights, auxiliary components and accessories, and motor starters.
- B. Rating: Conform to AHRI 550/590.
- C. Conform to ASME BPVC-VIII-1 for construction and testing of centrifugal chillers.
- D. Conform to ASHRAE Std 15 for safe construction and operation of centrifugal chillers.
- E. Energy efficiency for electrically operated, water-cooled units:
  - 1. Capacity: Less than 150 tons:
    - a. Integrated Part Load Value: 5.25.
    - b. Coefficient of Performance: 5.0.
  - 2. Capacity: Greater than or equal to 150 tons and less than 300 tons:
    - a. Integrated Part Load Value: 5.90.
    - b. Coefficient of Performance: 5.55.
  - 3. Capacity: Greater than or equal to 300 tons:
    - a. Integrated Part Load Value: 6.40.
    - b. Coefficient of Performance: 6.10.

### 2.04 COMPRESSORS

- A. Compressor Casing: Cast iron, horizontally or vertically split with machined passages and leak tested to 45 psig. Provide refrigerant sight glass.
- B. Impellers: Single or multi-stage, in-line design, fully shrouded, statically and dynamically balanced, tested to 20 percent over operating speed, mounted on heat treated forged or rolled steel shaft, nonferrous, labyrinth seals between stages.
- C. Guide Vanes: Modulating radial blade dampers, on each stage, with externally mounted electric operator, suitable for capacity reduction to 10 percent of specified load without hot gas bypass when supplied with design entering water quantity and temperature.
- D. Bearings: Steel or aluminum journal bearings, pressure lubricated.
- E. Gear Box: Double helical design, symmetrical and center supported by spherically seated, self aligning bearing, arranged for inspection without disassembly.
  - 1. Provide speed increasing transmissions for variable speed chillers to not exceed 10,000 rpm compressor speed.
- F. Motor: Hermetically sealed, singled speed, low slip induction type. Refer to Section 22 0513.
- G. Lubrication: Oil pump, with oil cooler, pressure regulator, oil filters, thermostatically controlled oil heater, and motor controls. Interlock to start before chiller motor and run after motor is shut down. Provide sight glass or electronic sensors for monitoring oil level.
- H. Refrigerant: Factory pre-charge unit with refrigerant specified above.

## **2.05 EVAPORATOR**

- A. Provide evaporator of shell and tube type, seamless or welded steel construction with cast iron or fabricated steel heads, seamless copper tubes or red brass tubes with integral fins, rolled or silver brazed into tube sheets. Position intermediate tube support sheets along length of shell to avoid contact and relative motion between adjacent tubes.
- B. Test and, where applicable, stamp refrigerant side for 45 psig working pressure and water side for 150 psig working pressure, in accordance with ASME BPVC-VIII-1.
- C. Provide marine type water boxes, machine welded to heat exchanger with tapped drain and vent connections, and flanged or mechanical joint connections arranged to permit inspection of tubes from either end without disturbing refrigerant and removable without disturbing water piping.
- D. Insulate evaporator and cold surfaces with 0.75 inch minimum thick flexible expanded polyvinyl chloride insulation with maximum K value of 0.28.
- E. Provide thermometer wells or thermistors for temperature controller and low temperature cutout.
- F. Design and construct evaporator to prevent liquid refrigerant from entering the compressor.
- G. Provide carbon rupture disc or relief valve on shell in accordance with ASHRAE Std 15.
- H. Construction and materials shall conform to ASME BPVC-VIII-1 or ASHRAE Std 15 as applicable to chiller manufacturer and chiller model.

## **2.06 CONDENSERS**

- A. Provide condensers of shell and tube type, seamless or welded steel construction with cast iron or fabricated steel heads, seamless copper tubes or red brass tubes with integral fins, rolled or silver brazed into tube sheets. Position intermediate tube support sheets along shell length to avoid contact and relative motion between adjacent tubes. Provide additional condensers on heat recovery units.
- B. Test and, where applicable, stamp refrigerant side for 45 psig working pressure and water side for 150 psig working pressure; in accordance with ASME BPVC-VIII-1.
- C. Provide marine type water boxes, machine welded to heat exchanger with tapped drain and vent connections, and flanged or mechanical joint connections arranged to permit inspection of tubes from either end without disturbing refrigerant and removable without disturbing water piping.
- D. Provide carbon rupture disc or relief valve on shell in accordance with ASHRAE Std 15.
- E. Provide baffles to ensure even distribution of incoming gas and to concentrate non-condensable gases.
- F. Construction and materials shall conform to ASME BPVC-VIII-1.

## **2.07 PURGE SYSTEM**

- A. Provide purge system on positive pressure units, incorporating a low temperature refrigeration system to automatically remove non-condensibles, water and air.
- B. System discharge shall be maximum 0.60 pound of refrigerant per pound of air discharged.

## **2.08 CONTROLS**

- A. Disconnect Switch: Factory mount disconnect switch in starter control panel.
- B. On or near chiller, provide microprocessor based control panel containing solid state, fully automatic operating and safety controls.
- C. Provide the following manufacturer's standard safety controls, including the following minimum functions, so that operating any one will shut down machine and require manual reset:
  - 1. Low evaporator refrigerant temperature.
  - 2. High condenser refrigerant pressure.
  - 3. Low oil pressure.
  - 4. Low refrigerant (evaporator) pressure.

- D. Provide the manufacturer's standard safety controls arranged so that operating any one will shut down machine and automatically reset.
- E. Provide the following devices on control panel:
  - 1. Manual Switches:
    - a. Machine off-auto switch.
    - b. Oil pump switch (manual or automatic).
    - c. Purge pump switch (manual-off-auto).
  - 2. Manual Set Point Adjustments:
    - a. Leaving chilled water temperature.
    - b. Current demand limit.
  - 3. Status Lights:
    - a. Chilled water flow proven.
    - b. Cooling required.
    - c. Unit running.
    - d. Unit loading.
    - e. Unit unloading.
    - f. Manual reset required.
    - g. Remote chilled water set point active.
    - h. Remote current water set point active.
  - 4. Setpoint and Temperature Display:
    - a. Current limit set point.
    - b. Entering evaporator water temperature.
    - c. Leaving evaporator water temperature.
    - d. Entering condenser water temperature.
    - e. Leaving condenser water temperature.
  - 5. Dial Type Pressure Gages:
    - a. Evaporator refrigerant pressure.
    - b. Condenser refrigerant pressure.
    - c. Low oil pressure (oil sump).
    - d. High oil pressure (oil supply).
- F. Provide the following operating controls:
  - 1. Solid state, chilled water temperature controller that controls electronic guide vane operator and hot gas bypass. Locate temperature sensor in entering chilled water.
  - 2. Adjustable thirty minute off timer prevents compressor from short cycling.
  - 3. Demand limit device to manually set maximum current infinitely between 40 percent and 100 percent of full load amperes.
  - 4. Automatic start that determines demand for chilled water from proof of chilled water flow and temperature differential between chilled water set point and supply temperature.

**2.09 VARIABLE SPEED DRIVE (VSD), UNIT MOUNTED**

- A. Furnish chiller with factory-mounted, liquid-cooled variable speed drive (VSD) shipped completely factory-assembled, wired, and tested.
- B. Specifically design VSD to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. VSD control logic is to optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If surge is detected, VSD surge avoidance logic is to make adjustments to move away from and avoid surge at similar conditions in the future.
- C. VSD Efficiency: 97 percent or better at full speed and full load.
- D. Fundamental Displacement Power Factor: Minimum of 0.96.
- E. Provide voltage and current regulated, solid state, microprocessor-based pulse-width modulated (PWM) VSD. Output power devices to be IGBT transistors.

- F. Provide liquid-cooled heatsink to cool the power semi-conductor and capacitor.
- G. Provide cleanable shell and tube heat exchanger with water-cooled design. Do not provide plate and frame heat exchanger.
- H. Furnish VSD in a NEMA Type 1 metal enclosure having a minimum short circuit withstand rating of 65,000 amps per UL 508. Include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory-installed bus bars and all components properly segregated and completely enclosed in a single, metal enclosure.
  - 1. Enclosure to include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.
  - 2. Entire chiller package to be listed by Underwriter's Laboratories Inc.
- I. VSD to be tested according to UL 508 and listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.
- J. Comply with recommendations stated in IEEE 519.
  - 1. Include integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than or equal to 5 percent as measured at the VSD input. If active filters are used to meet this requirement, then the losses associated with the filter are to be included in the chiller performance on the selection.
- K. Fundamental Displacement Power Factor: Minimum of 0.96.
- L. Voltage Input: Nominal 480 volts, three phase, 60 hertz AC, plus or minus 10 percent of nominal voltage.
- M. Line Frequency: 38 to 60 hertz.
- N. VSD to include the following:
  - 1. All control circuit voltages physically and electrically isolated from power circuit voltage.
  - 2. 150 percent instantaneous torque available for improved surge control.
  - 3. Soft start, adjustable linear acceleration, coast-to-stop.
  - 4. Adjustable current limiting and UL approved electronic motor overload protection.
  - 5. Insensitivity to incoming power phase sequence.
  - 6. VSD and motor protection from the following faults:
    - a. Output line-to-line short circuit.
    - b. Line-to-ground short circuit.
    - c. Phase loss at AFD input.
    - d. Phase reversal/imbalance.
    - e. Over-voltage.
    - f. Under-voltage.
    - g. Over-temperature.
- O. Include the following VSD status indicators available to facilitate startup and maintenance:
  - 1. Output speed in hertz and rpm.
  - 2. Input line voltage.
  - 3. Input line kW.
  - 4. Output/load amps.
  - 5. Average current in percent RLA.
  - 6. Load power factor.
  - 7. Fault.
  - 8. VSD transistor temperature.
- P. Service Conditions (at full output power; no external venting or heat exchangers required):
  - 1. Operating Ambient Temperature: Between 32 degrees F and 104 degrees F.
  - 2. Room Ambient Relative Humidity: Up to 95 percent.
  - 3. Elevation: Up to 3,300 feet. For every 300 feet above 3,300 feet, decrease the rated output current by one percent.

## 2.10 VARIABLE SPEED DRIVE (VSD), REMOTE-MOUNTED.

- A. Furnish chiller with remote (free-standing) mounted, air-cooled variable speed drive (VSD) shipped completely factory-assembled, wired, and tested.
- B. Specifically design VSD to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. VSD control logic is to optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If surge is detected, VSD is to move away from and avoid surge at similar conditions in the future.
- C. VSD Efficiency: 97 percent or better at full speed and full load.
- D. Fundamental Displacement Power Factor: Minimum of 0.97.
- E. Provide voltage and current regulated, solid state, microprocessor-based pulse-width modulated (PWM) VSD. Output power devices to be IGBT transistors.
- F. Provide liquid- or air-cooled heatsink to cool power semi-conductor and capacitor.
- G. Furnish VSD in a NEMA Type 1 metal enclosure having a minimum short circuit withstand rating of 65,000 amps per UL 508. Include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.
  - 1. Enclosure to include padlockable, door-mounted circuit breaker with minimum AIC rating of 65,000 amps.
  - 2. Entire chiller package to be listed by Underwriter's Laboratories Inc.
- H. VSD to be tested according to UL 508 and listed by a National Recognized Testing Laboratory (NRTL) as designated by OSHA.
- I. Comply with recommendations for harmonic mitigation.
  - 1. Include a DC link reactor on positive and negative rails to minimize power line harmonics and protect the VSD from power line transients.
- J. Voltage Input: Nominal 460 volts, three phase, 60 Hertz AC power, plus or minus 10 percent of nominal voltage.
- K. Line Frequency: 38 to 60 Hertz.
- L. VSD is to include the following features:
  - 1. All control circuit voltages physically and electrically isolated from power circuit voltage.
  - 2. 150 percent instantaneous torque available for improved surge control.
  - 3. Soft start, adjustable linear acceleration, coast-to-stop.
  - 4. Adjustable current limiting and UL-approved electronic motor overload protection.
  - 5. Insensitivity to incoming power phase sequence.
  - 6. VSD and motor protection from the following faults:
    - a. Output line-to-line short circuit.
    - b. Line-to-ground short circuit.
    - c. Phase loss at AFD input.
    - d. Phase reversal/imbalance.
    - e. Over-voltage.
    - f. Under-voltage.
    - g. Over-temperature.
- M. Include the following VSD status indicators available to facilitate startup and maintenance:
  - 1. Output speed in hertz and rpm.
  - 2. Input line voltage.
  - 3. Input line kW.
  - 4. Output/load amps.
  - 5. Average current in percent RLA.
  - 6. Load power factor.
  - 7. Fault.

8. VSD transistor temperature.
- N. Service Conditions:
1. Operating Ambient Temperature: Between 14 degrees F and 104 degrees F.
  2. Room Ambient Relative Humidity: Up to 95 percent.
  3. Elevation: Up to 3,300 feet. For every 3,300 feet above 3,300 feet, decrease the rated output current by 4 percent up to 9,900 feet.

## 2.11 STARTER

- A. Starter Manufacturers:
1. Eaton Electrical/Cutler-Hammer; \_\_\_\_\_: [www.eatonelectrical.com](http://www.eatonelectrical.com).
  2. GE Industrial; \_\_\_\_\_: [www.geindustrial.com](http://www.geindustrial.com).
  3. Schneider Electric Company; \_\_\_\_\_: [www.schneider-electric.com](http://www.schneider-electric.com).
  4. Square D \_\_\_\_\_.
  5. Substitutions: See Section 01 6000 - Product Requirements.
- B. On or near chiller, mount steel NEMA 1 type enclosure, containing Star-Delta closed transition starter, manufactured in accordance with chiller manufacturer's specifications and factory tested.
- C. Enclosure shall be designed for top or bottom cable entry with front access. Door, interlocked with circuit breaker, and shall accommodate padlock.
- D. Mount the following devices within enclosure:
1. Disconnect switch on line side with fuses.
  2. Standard interrupting capacity circuit breaker with ground fault protection.
  3. Pilot relays to start and stop compressor on signal from chiller control panel.
  4. Electronic overload provides overload protection, protects compressor motor from distribution system irregularities, and provides motor current signal to chiller capacity control module.
  5. Control power transformer.
  6. Fused control circuits for control circuit, oil pump motor, oil heater, and purge control unit.
  7. Contactor interlocks for communication between starter and control panel.
  8. Capacitors, one per phase, to correct power factor to minimum 95 percent.
  9. Fused disconnect and starter for oil pump.
  10. Relay for remote mounted emergency shut-down switch.
- E. Provide the following devices on starter door:
1. Starter fault trip indicator and reset.
  2. Overload trip indicator and reset.
  3. Distribution fault trip indicator and reset.
  4. Ground fault trip indicator and reset.
  5. Ammeters, one per phase.
  6. Voltmeters, one per phase.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Align chiller on concrete foundations, sole plates, and sub-bases. Level, grout, and bolt in place.
- C. Install units on vibration isolation.
- D. Provide evaporator connections to chilled water piping.
1. On inlet, provide:
    - a. Thermometer well for temperature controller.
    - b. Thermometer well and thermometer.
    - c. Strainer.
    - d. Nipple and flow switch.



- e. Flexible pipe connector.
- f. Pressure gage.
- g. Shut-off valve.
- 2. On outlet, provide:
  - a. Thermometer well and thermometer.
  - b. Flexible pipe connector.
  - c. Pressure gage.
  - d. Shut-off valve.
- E. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.
- F. Insulate evaporator and cold surfaces.
- G. Provide condenser connection to condenser water piping.
  - 1. On inlet, provide:
    - a. Thermometer well for temperature controller.
    - b. Thermometer well and thermometer.
    - c. Strainer.
    - d. Nipple and flow switch.
    - e. Flexible pipe connector.
    - f. Pressure gage.
    - g. Shut-off valve.
  - 2. On outlet, provide:
    - a. Thermometer well and thermometer.
    - b. Flexible pipe connector.
    - c. Pressure gage.
    - d. Shut-off valve.
- H. Arrange piping for easy dismantling to permit tube cleaning.
- I. Provide piping from chiller rupture disc to outdoors. Size as recommended by manufacturer.

### **3.02 SYSTEM STARTUP**

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Supply initial charge of refrigerant and oil.
- D. Demonstrate system operation and verify specified performance. Refer to Section 23 0593.

### **3.03 CLOSEOUT ACTIVITIES**

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Train operating personnel in operation and maintenance of units.
- D. Provide the services of the manufacturer's field representative to conduct training.

**END OF SECTION 23 6416**

