

SECTION 236416 - CHILLERS: CENTRIFUGAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification sections, apply to work of this section.

1.2 SCOPE

- A. Provide hermetic or open, electric drive, centrifugal water chillers of type, size, capacities, and operating characteristics indicated on drawings and specified herein. Include equipment and labor required for a complete and proper installation.

1.3 RELATION TO OTHER WORK

- A. Refer to the section, "General Mechanical Provisions", for related requirements. Refer to other sections of Division 23 and to all other applicable portions of the Drawings and Specifications.

1.4 SHOP DRAWINGS

- A. Include complete data on: unit dimensions; minimum operating and service clearances; capacities and rating conditions; operating weights; leveling devices and sole plates; waterside pressure losses and number and arrangement of passes and connections; power consumption; power and control wiring (both factory and field); starters. Where operating and safety pass arrangements which differ from those scheduled and indicated, or where waterside pressure losses which vary more than ten percent (10%) from the scheduled values, are proposed, it shall be the responsibility of the Contractor to provide comprehensive data (with chiller shop drawing submission) to show that piping changes and pump operating characteristics have been taken into account and that pumps will perform satisfactorily. Include field installation drawings of required auxiliary piping. Provide thermal limit curves (e.g. controller fuse curves and overload curves) and time vs. amps on starting.

1.5 WARRANTY

- A. Provide a standard unit parts and labor warranty for one year from startup or 18 months from factory shipment, whichever occurs first.
- B. A quote for a 10-year parts, labor, and refrigerant quality warranty covering all chiller components, to include starter and drive, must be supplied by the manufacturer to provide a comparative value of confidence in reliability. This quote must be of the manufacturer's warranty; third party insurance/warranty quotes are not acceptable.
- C. Chiller manufacturer shall provide whole unit parts, whole unit labor, and refrigerant quality warranties for a period of 10 years from start-up. The warranty must be provided by the manufacturer; third party insurance/warranty coverage is not acceptable. The chiller manufacturer shall provide an original factory warranty certificate for each chiller listing as a minimum chiller model, serial number, and warranty information as specified. Payment shall

not be released until the owner receives original certificates. Warranty coverage is per the factory, not local sales offices. Validated service and scheduled maintenance performed by acceptable servicing companies per manufacturer required.

1.6 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Provide on-site instruction by an authorized representative of the chiller manufacturer. Instruction shall be given to Owner's designated operating and service personnel and receipt of same shall be acknowledged in writing prior to request for final payment.

1.7 DELIVERY AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, chiller loading, local transportation requirements, unloading, storage, and final setting.
- B. Protect chiller and controls from physical damage. Leave factory shipping covers in place until installation. The entire unit must be shrink wrapped with an environmentally recyclable material standard. The material shall include an imbedded desiccant to minimize/eliminate internal moisture.

1.8 CERTIFIED RATING

- A. Be rated in accordance with ARI Standard 550-77 for Centrifugal Water-Chilling Packages.

1.9 CAPACITIES AND OPERATING CONDITIONS

- A. General: As scheduled on drawings or as otherwise indicated.

1.10 MANUFACTURERS AND DESIGN BASIS

- A. Products listed in this Section or on the plans are based on a specific manufacturer to establish the desired style, quality and type. Equivalent products, complying with the requirements of this Section and the installation requirements of the plans, by the following manufacturers are acceptable:
 - 1. Trane
 - 2. Carrier
 - 3. York

PART 2 - PRODUCTS

2.1 SUMMARY

- A. Description: Factory-assembled and tested water chiller complete with compressor, evaporator, condenser, controls, starter or variable speed drive, interconnecting unit piping and wiring, indicating accessories, and mounting frame. Performance shall be per specification section 3.03 schedule.

- B. The contractor shall furnish and install centrifugal water chillers as shown and scheduled in the plans and specifications. The units shall produce the specified tonnage per the scheduled data in accordance with the latest revision of AHRI 550/590. The unit shall bear the AHRI certification label as applicable.
- C. Base bid shall be Trane Agility chiller with approved alternate being [York, Daikin, Carrier]. Job awarded on basis of specified machine. Alternate will be considered after the job is awarded.
- D. Chiller shall be as manufactured by Trane.
- E. Unit shall be painted in accordance with the manufacturer's standard procedures and practices.

2.2 COMPRESSOR AND MOTOR

- A. The compressor shall be centrifugal with multiple stages.
- B. If magnetic bearings are used, the chiller must provide backup power to the magnetic bearings with a UPS system that provides power conditioning, to completely isolate the magnetic bearing system from utility power, enabling error-free operation during surges, sags, spikes, and other power anomalies.
- C. The motor shall be hermetic and either suction, interstage, or liquid refrigerant cooled. Hot gas motor cooling is not acceptable. If an open motor design is used, then the manufacturer shall provide and install a complete chilled water AHU with a capacity equal to 0.9% of the chiller's tonnage to serve the chiller area, which must be completely operational and include all wiring and automatic temperature controls. The open motor chiller manufacturer must also increase chiller size by an equivalent tonnage with no increase in specified full load kW, and shall list, on the submittal, additional maintenance requirements due to alignment, refrigerant shaft seal, coupling and bearings. Additionally, if an open drive motor is provided, a motor-compressor shaft seal leakage containment system shall be provided with the following inclusions:
 - 1. An oil reservoir shall collect any oil and refrigerant that leaks past the seal.
 - 2. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing.
 - 3. Manufacturer shall warrant the shaft seal, reservoir, and float valve system against leakage of oil and refrigerant to the outside of the chiller for a period of 10 years from initial start-up, including parts and labor to replace a defective seal and any refrigerant required to trim the charge to original specifications. Inspections shall be performed a minimum of once a year. See Section 1.05 for more information in warranty.
- D. The impellers shall be fully shrouded and made of a high strength aluminum alloy.

2.3 EVAPORATOR AND CONDENSER

- A. The evaporator and condenser shall be built in accordance with ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration and ASME section VIII as applicable.
- B. The evaporator tubes shall be internally and externally enhanced with a 0.75" outer diameter. The tubes shall be securely supported at intermediate supports and physically expanded into both ends of the tube sheets.

- C. The condenser tubes shall be internally and externally enhanced with a 0.75" outer diameter. The tubes shall be securely supported at intermediate supports and physically expanded into both ends of the tube sheets.
- D. The evaporator tubes must be removable from both ends to provide easy access for tube cleaning. The minimum evaporator tube wall thickness, root-to-root across the entire tube length shall be 0.025".
- E. The minimum condenser tube wall thickness, root-to-root across the entire tube length shall be 0.025".
- F. The evaporator water piping connections shall be Victaulic.
- G. The condenser water piping connections shall be Victaulic.
- H. Provide evaporator water box designed for 150 psig maximum waterside working pressure. Waterside shall be hydrostatically tested at 1.5 times design working pressure.
- I. Provide condenser water box designed for 150 psig maximum waterside working pressure. Waterside shall be hydrostatically tested at 1.5 times design working pressure.
- J. The evaporator and condenser shall both have a flow turndown of XX:YY.
- K. The evaporator water boxes shall be standard non-marine type with connections per the schedule.
- L. Insulation will be 3/4" insulation and cover all low-temperature surfaces to include the evaporator, water boxes, suction elbow, and economizer if applicable.
- M. Units with multi-stage compressors shall incorporate an interstage 'economizer'. All units with single stage compressors shall have the condensers circuited for liquid subcooling and controlled through the use of condenser liquid level control.
- N. Adjustable or float type refrigerant metering devices and thermal expansion valves (TXV) shall be inspected and adjusted by the manufacturer annually for the first five years of operation to assure equivalent reliability to an electronic expansion valve (EXV) system. A written report shall be forwarded to the owner each year over the first five years to confirm completion of calibration.

2.4 REFRIGERANT CIRCUIT

- A. All units shall have 1 refrigerant circuit with a single compressor. If manifolded compressors are provided, then individual compressor warranties must be provided for each compressor motor.
- B. An electronically controlled expansion valve (EXV) is provided to maintain proper refrigerant flow.

2.5 CONTROLS

- A. The chiller shall be controlled by a unit mounted, stand-alone Direct Digital Control (DDC) system. A dedicated chiller microprocessor control panel is to be supplied with each chiller by the chiller manufacturer.

- B. Enclosure shall be unit mounted NEMA 250 Type 1.
- C. A color, touch sensitive liquid crystal display (LCD) shall be unit mounted and a minimum of 12.1" diagonal. The display shall be fully adjustable in height and viewing angle. Animated graphical representations of chiller subsystem operation shall be used to enhance the user interface.
- D. Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor, evaporator, condenser and motor information as well as associated diagnostics. The controller shall display all active diagnostics and a minimum of 20 historical diagnostics.
- E. Control authority must be capable of handling at least four conditions: Off, local manual at the chiller, local automatic at the chiller and automatic control through a remote source.
- F. Capability to connect a laptop to service utility with applicable software from manufacturer and obtain enhanced set-up and diagnostics.
- G. The front of the chiller control panel shall display the following in clear language, without the use of codes, look-up tables, or gauges:
 - 1. Run time
 - 2. Number of starts
 - 3. Current chiller operating mode
 - 4. Chilled water set point and set point source
 - 5. Electrical current limit set point and set point source
 - 6. Entering and leaving evaporator water temperatures
 - 7. Entering and leaving condenser water temperatures
 - 8. Saturated evaporator and condenser refrigerant temperatures
 - 9. Evaporator and condenser refrigerant pressure
 - 10. Compressor motor current per phase
 - 11. Compressor motor percent RLA
 - 12. kW energy consumption and power factor
 - 13. Compressor motor winding temperatures per phase
- H. The chiller control panel shall provide password protection of all setpoints.
- I. The chiller control panel shall provide individual relay outputs to start/stop the evaporator and condenser water pumps. The condenser water pump relay output can be used to enable the cooling tower temperature controls.
- J. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.
- K. The chiller control panel shall be capable of displaying system data in I-P or SI units.
- L. The chiller manufacturer shall include a pressure, non-mechanical based unit mounted flow switch that is of the thermal dispersion type for the condenser to verify flow through the unit.
- M. The chiller manufacturer shall include a pressure, non-mechanical based unit mounted flow switch that is of the thermal dispersion type for the evaporator to verify flow through the unit.
- N. Safeties - the chiller control panel shall provide the following safeties:
 - 1. Low chilled water temperature
 - 2. Low evaporator refrigerant temperature or pressure

3. High condenser refrigerant pressure
 4. Evaporator and condenser water flow status
 5. R-164High motor winding temperatures
 6. High motor current
 7. AFD function faults
 8. Sensor faults
 9. Unit controls operation
 10. The chiller control panel or starter shall incorporate advanced motor protection to safeguard the motor throughout the starting and running cycles from the adverse effects of:
 - a. Current phase loss
 - b. Current phase unbalance
 - c. Current phase reversal
 - d. Under/Over voltage
 - e. Motor current overload
 - f. Distribution fault protection with auto restart consisting of three-phase current sensing devices that monitor the status of the current
 - g. AFD communication-control failure
- O. The chiller control panel shall be capable of providing short cycling protection.
- P. The chilled water controller of each chiller shall include variable water-flow capability to allow the chiller to respond quickly to accelerating or decelerating water, and have the following features:
1. It shall allow control of the leaving chilled water temperature to within +/- 1.0°F (0.3°C) at a water flow rate change of 10% per minute and will stay online at a water flow rate change of 30% per minute.
- Q. The chiller, upon power loss restoration, must be able to start the compressor within 65 seconds. The chiller time to fully load up to 80% shall be no longer than 4 minutes. The manufacturer shall supply documentation to support their ability to do this.
- R. The chiller control panel shall provide a relay output that shall energize whenever the compressor is running.
- S. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.
- T. The chiller control panel shall provide a relay output that shall energize whenever the chiller is operating at maximum capacity.
- U. The chiller control panel shall provide a head relief request relay output to indicate that the chiller is in condenser limit mode and thereby requesting condenser water temperature relief.
- V. The chiller control panel shall provide an analog [2 - 10VDC] [4 - 20mA] output signal that shall indicate the Compressor Motor Percent RLA.
- W. The chiller control panel shall allow for an analog input for a chilled water setpoint and an electrical current limit set point. These setpoints can be in the form of 4-20 mA or 2-10 Vdc signals from a remote source (i.e. generic building automation system).
- X. The chiller control panel shall provide an analog output signal that shall indicate the condenser refrigerant pressure or condenser/evaporator differential refrigerant pressure.

- Y. The chiller controller must be able to communicate directly to a building automation system using BACnet protocol (MSTP-RS 485/IP).

2.6 VARIABLE SPEED DRIVE (VSD), UNIT MOUNTED

- A. The water chiller shall be furnished with an variable speed drive (VSD) as shown on the drawings. The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.
- B. The VSD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VSD control logic shall optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, VSD surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.
- C. The VSD efficiency shall be 97% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.96 at all loads.
- D. The VSD shall be solid state, microprocessor based pulse-width modulated (PWM) design. The VSD shall be voltage and current regulated. Output power devices shall be IGBTs.
- E. Power semi-conductor and capacitor cooling shall be from a combination of liquid cooled heatsink and air flow.
- F. The VSDs shall each be furnished in a metal enclosure having as minimum a short circuit withstand rating of 65,000 amps per UL 508A. It will 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 shall include a padlockable, door-mounted circuit breaker with a minimum AIC rating of 65,000 amps.
 - 2. The entire chiller package shall be UL/CUL listed.
- G. The VSD panel shall be tested to ANSI/UL Standard 508A and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.
- H. Input shall be nominal 480. V, three phase, 60. Hz AC power.
- I. Line voltage tolerance +/-10% and line frequency tolerance +/-1%
- J. The VSD shall include the following features:
 - 1. All control circuit voltages are physically and electrically isolated from power circuit voltage.
 - 2. Soft start, adjustable linear acceleration, controlled ramp-down to stop.
 - 3. Insensitivity to incoming power phase sequence.
 - 4. Adjustable current limiting and U.L. approved electronic motor overload protection.
 - 5. Output line-to-line short circuit protection.
 - 6. Line-to-ground short circuit protection.
 - 7. Protection from phase loss at AFD input.
 - 8. Protection from output phase reversal/imbalance.
 - 9. Protection from over/under-voltage.
 - 10. Protection from over-temperature.

- K. The following VSD status indicators shall be available to the unit controller to facilitate startup and maintenance:
1. DC Bus voltage.
 2. Output/load amps.
 3. Fault.
- L. Service Conditions:
1. Operating ambient temperature of 14°F - 104°F (-10°C - 40°C).
 2. Room ambient up to 95% relative humidity.
 3. Elevation to 3300 feet (1000 meters). For every 300 feet (90 meters) above 3300 feet, the rated output current shall be decreased by 4% up to 9900 feet.

PART 3 - EXECUTION

3.1 UNIT PLACEMENT

- A. Locations shall be essentially as shown on drawings; however, actual placement shall be verified using field measurements and data relating to equipment approved for actual installation.

3.2 HOUSEKEEPING PADS

- A. Provide six inch high reinforced (#4's @ 12" both ways with 1-1/2" to cover) concrete housekeeping pads for each individual machine. Pads shall extend six inches beyond the machine bases in all directions and be continuous beneath the machine. Pads shall have chamfered edges and shall be poured and finished smooth and level to insure proper and continuous support for the bearing surfaces of the machine.

3.3 PIPING

- A. Provide all piping, hangers, supports, valves, and specialty items required for a complete and operable system. Include, but not be limited to, installation of thermometers to indicate entering and leaving chilled water temperatures and entering and leaving condenser water temperatures; gauge connections and gauge cocks to read pressure drop across cooler (evaporator) and condenser; installation of manual air vents and drains on all heads and water boxes; and piping of all relief valves (full size of connections) to the exterior. Provide isolation valve in each pipe to differential pressure switch at cooler and evaporator.

3.4 REFRIGERANT AND OIL

- A. Before, during and after startup and testing machines shall be completely charged with refrigerant and oil and all quantities involved logged.

3.5 STARTUP SERVICE

- A. Provide factory trained representatives of chiller and controller manufacturers for checkout and startup service. Controller service representative and chiller service representative shall inspect switchgear installation and all wiring and shall verify all control adjustments prior to

startup. After certifying correctness of the electrical installation, the two service representatives shall jointly perform initial startup and checkout and log all pertinent data for each individual machine. In addition to checkout and startup work covered hereinbefore, chiller manufacturer's service representative shall supervise leak testing, evacuation and dehydration (using high vacuum pump furnished by the manufacturer), and charging the unit with refrigerant and oil.

END OF SECTION 236416