SECTION 236416 - CENTRIFUGAL WATER CHILLERS – AIR COOLED

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes design, performance criteria, refrigerants, controls, and installation requirements for air cooled centrifugal chillers.

1.2 REFERENCES

Compliance is with the following codes and standards:

1. AHRI 550/590
2. ANSI/ASHRAE 15
3. ASME Section VIII
4. ETL Listed
5. ANSI UL 1995
6. CSA C22.2 No. 236 (Canada)

1.3 PERFORMANCE REQUIREMENTS

A. Unit shall consist of one or more magnetic bearing oil-free centrifugal compressors with integrated variable frequency drive, refrigerant flooded evaporator, air cooled condenser, and operating controls with equipment protection.

B. Performance: Refer to schedule for specific operating conditions

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude. Site altitude for this installation is ___.

A. D. Chiller shall be equipped for single-point power connection.

B. Performance Tolerance: Comply with the following in lieu of ARI 506/110:

1. Allowable Capacity Tolerance: Standard AHRI tolerance applies.
2. Allowable IPLV/NPLV Performance Tolerance: Standard AHRI tolerance applies.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Dimensioned plan and elevation drawings, including required service clearances and location of all field piping and electrical connections.

2. Performance at ARI standard conditions and at conditions indicated.

3. Electrical and water quality requirements during operation, standby and shutdown.

4. Control system diagram showing points for field interface and connection to external BMS systems. Drawings shall show field and factory wiring.

5. Installation and Operating Manuals

6. Minimum and Maximum evaporator flow rate.

7. Refrigerant capacity of chiller.

8. Fluid capacity of evaporator, condenser.

9. Characteristics of safety relief valves.

10. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, and methods of field assembly, components, and location and size of each field connection.
11. Wiring Diagrams: For power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Manuals: For each chiller to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 550 certification program.

B. ARI Rating: Rate chiller performance according to requirements in ARI 506/110.

C. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.

F. Comply with National Electrical Code.

G. Comply with requirements of ETL and include label by a qualified testing agency showing compliance.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

B. Package chiller for domestic shipping with a North America destination. Export packaging and shipping is available.

1.8 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller not including refrigerant.
b. Complete compressor and drive assembly
c. Parts and Labor

2. Warranty Period: One Year Parts and Labor from date of Substantial Completion.

3. Optional - Five years Parts and Labor from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Arctic Cool Chillers or approved equal utilizing Danfoss Turbocor compressors in equal number for maximum unloading capability.

2.2 MANUFACTURED UNIT

A. Description: Factory-assembled and tested chiller complete with compressor, compressor motor, compressor chiller controller, evaporator, condenser, controls, interconnecting unit piping and wiring, and indicated accessories.

B. Chiller Frame and Housing - All components shall be mounted onto a unitized construction, welded steel base frame being Epoxy painted with powder coated formed galvanized sheet metal structure supports suitable for outdoor installation. Compressors and controls shall be contained within a sheet metal enclosure to protect critical components from the weather.

1. Optional - Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.

2. Optional – Provide multiple point power connection.

3. Optional – Provide low profile designs with staggered or side-by-side, evaporator and condenser, based on capacity.

C. DESIGN REQUIREMENTS

Unit shall consist of one or more magnetic bearing oil-free centrifugal compressors with integrated variable frequency drive, refrigerant flooded evaporator, , and operating controls with equipment protection.

1. Performance: Refer to schedule for specific operating conditions. All ratings are measured at standard AHRI entering condenser air temperatures and without utilizing hot gas bypass.

2. Acoustics: Refer to the schedule for Sound pressure level. Sound data shall be measured according to AHRI Standard 370 .

3. Chiller shall be equipped for single-point power connection, unless otherwise specified.

4. In order to allow for variable chilled water flow and to facilitate chilled water pump energy savings the evaporator shall be designed to allow the flow rate to be reduced to the minimum flow rate specified on each project performance selectio (Schedule).

5. Each compressor shall be electrically and mechanically isolated so that if a compressor fails or needs service, it can be serviced or removed from the chiller without disabling the other compressors or the chiller and allowing the chiller to remain in operation with the other compressor(s) on-line.

6. The chiller shall be provided with at least the number of compressors shown on the schedule. . It will be the manufacturer's responsibility to coordinate space and piping requirements with the contractor.

2.3 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.

B. Compressor:
1. Compressors shall be of semi-hermetic centrifugal design and operate oil-free with two-stages of compression, magnetic bearings, movable inlet guide vanes and integrated variable frequency drive system.
2. Automatically positioned and controlled inlet guide vanes shall operate with compressor speed controls

3. The compressor shall be capable of coming to a controlled stop in the event of a power failure. The unit shall be capable of initializing an automatic restart in the case of a power failure
4. Each compressor shall have integrated microprocessor control capable of capacity and safety
5. Each compressor shall be installed with individual suction, discharge and motor cooling refrigerant line isolation valves. Chillers without discharge line isolation valves that rely on non-return valves in the discharge line for compressor removal shall not be accepted.
6. Each compressor shall have an individual disconnect switch. The compressor shall have mechanical and electrical isolation to allow the chiller to operate when a compressor is removed from the machine, on chillers that are provided with more than one compressor.
7. Compressor motor and chiller unit shall include variable-frequency speed controls to match cooling load demand to compressor speed and inlet guide vane position.
8. Each compressor shall be equipped with an AC line reactor and individual disconnect.

2.4 REFRIGERATION

A. Refrigerant:

1. Type: 134a.
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

2.5 EVAPORATOR

A. Description: The evaporator shall be shell-and-tube flooded type with refrigerant in the shell and water inside the tubes. Heat exchangers shall be designed, constructed, tested and stamped in accordance with the requirements of ASME Code, Section VIII Code Case 1518-5. Heat exchanger tubing shall have a copper wall thickness of 0.64 mm (0.025 in.). The water sides shall be designed for a minimum of 1000 kPa (145 psig) or as specified. The water connections for the evaporator and condenser shall be either grooved suitable for Victaulic couplings or flanged as detailed herein. Vents and drains shall be provided. The refrigerant side of each vessel shall bear the ASME Code stamp, code case section VIII.

Vessels shall pass a test pressure of 1.1 times the working pressure but be not less than 689 kPa (100 psig). Provide intermediate tube supports spaced to enable equal liquid and gas flow across multiple compressor suction ports.

B. Tubes shall be individually replaceable and have internally and externally enhanced surfaces designed for refrigeration duty. Tubes shall have smooth full tube wall landings at the tube-sheet ends and at intermediate tube supports. Tubing without full wall thickness landings shall not be accepted. Tubes shall be mechanically roller expanded into steel tube sheets containing a minimum of three concentric grooves

C. To ensure effective liquid droplet removal, prevent liquid damage to compressors, and equalize suction pressure across evaporators with multiple compressors, a perforated plate designed for vapor disengagement shall be installed inside the evaporator above the tubing.

D. The evaporator shall be provided with spring loaded reseating-type pressure relief valves according to ASHRAE-15. Rupture disks are not acceptable.

E. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

F. Designed to prevent liquid refrigerant carryover from entering compressor.

G. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.

H. Minimum evaporator exiting water temperature shall be 3.3°C (38°F), unless otherwise specified and accepted by the chiller manufacturer.

I. Factory-mounted and wired water flow switches shall be provided on the evaporator in order to prevent unit operation with no water flowing through the heat exchangers.

J. Optional – Provide marine type water boxes to enable cleaning of water tubes.

K. Optional – Provide epoxy-coating of inside surfaces of water boxes and tube sheets.

L. Optional – Provide water side vessel design for 300 psi operation.

M. Optional – Provide 1-1/2” closed cell insulation onto evaporator shell, water boxes and connections.

2.6 AIR COOLED CONDENSER

A. To provide normal and energy efficient operation in the widest range of ambient temperatures air-cooled chillers shall have dedicated and discrete refrigeration circuiting for each compressor. Air cooled packaged chillers and controls shall be capable of reliable operation between 32°F and 110° ambient air temperature. Chillers that have more than one compressor sharing a single circuit and set of refrigerant controls shall not be acceptable.

B. Air-cooled condensers shall utilize aluminum fins with refrigeration duty copper tubes mechanically expanded into fin collars. Condenser coils shall be arranged in a W-configuration or V configuration to reduce equipment footprint.

C. Condenser coils and fans shall be arranged such that one fan operates with one coil section so that the failure of a fan will not affect the CFM across any coil beyond that fan.

D. Condenser shall be equipped with packaged fixed or variable speed fans capable of delivering specified CFM of air according to ARI standard operating conditions.

E. Fans shall be EC type with built-in variable-speed motors. To increase coil efficiency and reduce air recirculation, fans shall be rated for 16,000 nominal CFM at full speed. Fans and assemblies shall be designed to operate at reduced noise levels. Fans shall be balanced dynamically and statically and utilize direct variable-speed drives. Fan blades shall be manufactured with corrosion resistant materials. Fan assemblies shall utilize full airfoil cross section design, providing vertical air discharge from extended orifices. The guards shall be constructed of heavy duty 14-gauge steel and painted.

F. OPTION – Fans shall be equipped with factory installed fan diffusers to reduce fan noise and increase power efficiency.

G. Refrigerant Economizer – Each dedicated refrigerant circuit shall include refrigerant components dedicated fan arrays. In order to assure reliable and efficient operation in higher ambient temperatures, each refrigeration circuit shall include a refrigerant to refrigerant brazed plate heat exchanger to provide cooled refrigerant gas injection between compressor impeller stages.

2.7 FREE-COOLING SYSTEM - OPTIONAL

A. System design – The chiller shall be designed with air cooled chilled water fluid coolers in parallel with the refrigerant condensers within each refrigerant circuits. The fluid cooler coil and the condenser coil shall be configured such that air flow passes the fluid cooler coil first then the condenser coil. The chiller system shall include a 3-way motorized modulating valve to control chilled water flow through fluid cooling coils or through the refrigerant evaporator. The system shall be designed to provide pre-cooling, mixed mode cooling and full compressor-less free-cooling utilizing threshold set-points for ambient and chilled water set points.

B. Free-Cooling Controls – The chiller controls shall have four modes of operation.
   1. Full Mechanical Mode - All compressors, refrigeration circuits and fans are set to provide mechanical cooling.
   2. Mechanical Mode - The fans in the associated fan bank provide condenser coil cooling only.
   3. Pre-Cool Mode - allows the fan banks to operate independently such that some of the fan banks provide free cooling and others provide mechanical cooling.
   4. Free-Cool Mode - Ambient air provides enough cooling capacity without the need to engage the compressors. In this mode, the fans and 3-way valve modulate to control the chilled water temperature at set-point.

C. Sequence Description
   1. If the ambient temperature is higher than the mechanical threshold setting, then the motorized 3-way valve shall cause full fluid flow to bypass and cooling capacity shall be provided by compressors.
   2. If the ambient temperature is less than the free-cooling threshold the 3-way valve shall operate to satisfy cooling demand and setpoint. Cooling capacity is provided by both fluid coolers and mechanical cooling where fluid coolers are allowed to provide as much capacity as they are able to provide with mechanical cooling providing the balance. Refrigerant and fan circuits shall be staged according to either mechanical refrigeration condensing or pre/free cooling duty.
   3. Setpoint Control - The controller shall recalculate the saturated discharge setpoint continuously based on ambient temperature and optionally compressor capacity.

2.8 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

   1. Thickness: ¾”

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

   1. Apply adhesive to 100 percent of insulation contact surface.
   2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
   3. Seal seams and joints to provide a vapor barrier.
   4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

2.9 LIQUID LEVEL CONTROLS

A. Control of refrigerant flow shall utilize a single or multiple 6,000 step electronic expansion valve (EXV), to operate within the full range from full load to the lowest loading capacity for the chiller. Fixed orifice metering devices or float controls using hot gas bypass are not acceptable. The EXV liquid line shall have a sight glass with moisture indicator and temperature sensor connected to the control system for validation of sub-cooling.

B. Design shall provide a positive liquid seal to ensure effective cooling of the compressor.

C. Optional - Load balancing valves shall be provided for capacity control and additional temperature stability.

D. Optional - The chiller shall be equipped with a backup valve to channel discharge gas from the outlet of the compressor to the evaporator, in order for the ramp up during a high-pressure ratio application.

2.10 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000 VA

C. Terminal blocks with numbered wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

2.11 CHILLER CONTROLS

A. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

B. The controller fitted to the oil-free centrifugal chiller package shall be an embedded real-time microprocessor device that utilizes control software written specifically for chiller applications. User operation shall be accomplished using a panel mounted color touch-screen interface. The status of the compressors and all system parameters including compressor alarms and temperature trends shall be viewable.

C. Multiple compressors staging algorithm shall operate at the optimized power curves of each compressor simultaneously and shall reset automatically every second during operation. Compressor staging methods that operate using simple incremental percent of demand shall not be accepted.

D. Chiller control software shall employ an active fault avoidance algorithm to reduce chiller capacity and/or power level in the case of the chiller approaching within 10% of any trip limit value such as suction pressure, discharge pressure, chiller amp limit, leaving chilled water temperature limit, etc.

E. Controller features must include the following:
   1. 10 inch, 65,000 colors touch screen operator interface.
   2. Chiller documentation shall be viewable via touch panel in pdf format.
   3. Operator interface shall be capable of connecting directly to compressors via serial communication protocol and displaying compressor information using Turbocor compressor monitoring / commissioning software.
   4. The chiller control panel shall contain a minimum of three processors, all control functionality shall be carried out on a dedicated real time processor, and data shall be served to a remote graphical user interface via an open Ethernet protocol. Proprietary protocols between any pc based and micro based processor are strictly prohibited.
   5. Chiller controls shall be BacNet capable via MSTP or IP. Complete configuration of native BAS communications via Modbus RTU, Modbus TCP/IP, BacNet MSTP and BacNet IP shall be made via standard chiller controller graphical user interface.

6. Chiller control shall be capable of controlling more than 2 (up to eight) Turbocor compressors on up to eight individual refrigerant circuits serving the same chilled water stream.
7. Real time chiller control processor shall be capable of e-mailing a predefined list of recipients, should a fault occur. E-mail shall include details of fault, possible reason for fault, attachment of a monthly data log of 195 or more compressor and chiller variables at a minimum of 30 second intervals, and indication of fault severity.
8. Ability to place all outputs in a manual state (hand, off, auto) via graphical user interface.
9. Alarm screen shall be capable of filtering faults into specific categories such as compressor, chiller and system faults in order to provide rapid diagnosis, and separation of failure modes.
10. Multiple compressor staging algorithm shall operate at the optimized power curves of each compressor simultaneously and shall reset automatically every second during operation. Compressor staging methods that operate using simple incremental percent of demand shall not be accepted.
11. Continuous data logging for operational trending and bin analysis shall be exportable to "CSV" format.
12. Built-in stepper motor controls for EXVs.
13. Controls lockup protection.
14. Three levels of alarm safety for minimum chiller down time.
15. Chiller control software shall employ an active fault avoidance algorithm to reduce chiller capacity and / or power level in the case of the chiller approaching within 10% of any trip limit value such as suction pressure, discharge pressure, chiller amp limit, leaving chilled water temperature limit, etc.
16. Real time data trending viewable via touch panel.
17. Controls shall identify within 60 seconds, a compressor that is not starting or ramping-up properly. Upon this identification, the compressor shall be disabled, the remaining compressors shall be operated in an optimized manner, and an alarm shall be sent to alert the operator.

F. Enclosure: Unit mounted, NEMA 250 Type 1 hinged enclosure, factory wired with a single-point, field-power connection and a separate control circuit.

G. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

1. Date and time.
2. Operating or alarm status.
3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.
6. Operating hours.
7. Number of chiller starts.
8. Outdoor-air temperature or space temperature if required for chilled-water reset.
9. Entering- and leaving-fluid temperatures of evaporator and condenser.
10. Difference in fluid temperatures of evaporator and condenser.
11. Fluid flow of evaporator

12. Refrigerant pressures in evaporator and condenser.
13. Refrigerant saturation temperature in evaporator and condenser
14. Compressor refrigerant suction and discharge temperature.
15. Phase current.
16. Percent of motor rated load amperage.
17. Phase voltage.
18. Demand power (kilowatts).
19. Energy use (kilowatt-hours).

H. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return water temperature.
3. Current limit and demand limit.
4. External chiller emergency stop.

I. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

1. Low evaporator pressure. High condenser pressure.
2. Low evaporator fluid temperature.
3. High compressor-discharge temperature.
4. Loss of evaporator fluid flow.
5. Motor overcurrent.
6. Motor overvoltage.
7. Motor undervoltage.
8. Motor phase reversal.
9. Motor phase failure.
10. Sensor- or detection-circuit fault.
11. Processor communication loss.
12. Motor controller fault.
13. Extended compressor surge.

J. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

K. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

L. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

M. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer or notebook computer.

N. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

O. Optional – Provide secure VPN Internet access to the chiller's controls via hard-wired Ethernet or WiFi using a dedicated, subscription-based data-only modem from a major provider such as Verizon or T-Mobile.

2.12 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
   1. Paint surfaces that are to be insulated before applying the insulation.
   2. Paint installed insulation to match adjacent uninsulated surfaces.

B. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

2.13 ACCESSORIES

A. Flow Switches:

   1. Chiller manufacturer shall furnish a switch for each evaporator and verify field-mounting location before installation.

   2. Pressure Differential Switches:

      a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
      b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
      c. Set Point: Screw type, field adjustable.
      d. Electrical Connections: Internally mounted screw-type terminal blocks.
      e. Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

2.14 SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

B. Optional – Perform four-point standard factory performance test on all scheduled chillers, before shipping, according to ARI 506/110.

   1. Test the following conditions:

      a. Design conditions indicated.
      b. Reduction in capacity from design to minimum load in steps of 100%, 75%, 50% and 25% with condenser fluid at design conditions.

2. Allow owners representative access to place where chillers are being tested. Notify 10 days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

END OF SECTION 236416