

SECTION 15652

REFRIGERATION-HERMETIC CENTRIFUGAL CHILLER

PART 1 GENERAL

1.1 SUMMARY

- A. Provide labor, materials and equipment necessary to furnish the indicated factory assembled and tested, packaged, self-contained, HERMETIC CENTRIFUGAL CHILLERS, including accessories as required for a complete, properly functioning, installation.
- B. Related Work Specified Under Other Sections
 - 1. General Mechanical Requirement - SECTION 15050.
 - 2. Aboveground Piping Systems - SECTION 15105.
 - 3. Electrical Work - 16000 Series SECTIONS

1.2 QUALITY ASSURANCE

- A. Standards
 - 1. The equipment and installation shall comply with the applicable portions of current editions of the following standards.
 - a. ARI 550/590 for performance rating of centrifugal and rotary chillers.
 - b. ANSI/ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.
 - c. Evaporator and condenser shall include an ASME "U" stamp and nameplate certifying compliance with ASME section VIII, Division 1 Code for Unfired Pressure Vessels as applicable for construction and testing of centrifugal chillers
 - d. Controls shall comply with the requirements of FCC rules and Regulations Part 15, subpart 1 for radio frequency emissions of Class 'A' devices
 - e. ASHRAE Standard 34 – Number Designation and Safety Classification of Refrigerants.
 - f. ARI Standard 575 – Method of Measuring Machinery Sound and Vibration within Equipment Rooms.
 - g. ARI Standard 740 – Refrigerant Recovery/Recycling Equipment.
 - h. UL Listed and labeled.
- B. Requirements Of Regulatory Agencies
 - 1. Provide materials and equipment and execute the WORK, including test and inspections, per applicable provisions of Federal, State and local Government laws and ordinances and referenced codes and standards. Governing laws, ordinances, codes and standards constitute minimum requirements.
- C. Source Quality Control
 - 1. Perform manufacturer's standard shop tests for each component to ensure compliance with intent of these SPECIFICATIONS.

2. Each chiller shall be factory performance tested by the chiller manufacturer:
 - a. Chillers shall meet the specified minimum tonnage (1250 tons) at 85 F condensing water temperature with 42 f leaving evaporator water temperature. Flow rates shall be as specified on drawing M-611. There shall be zero tolerance at meeting capacity (1250 tons) at 85 F. Efficiency specified on drawing M-611 schedule shall be meet with ARI tolerances at 85 F condenser water temperature. Efficiency at part loads shall be determined by calculations and test procedure outlined in ARI 550/590 within tolerances allowed by the ARI 550/590 standard.
 - b. One machine will be tested at 65 F, 85 F and 90.9 F condensing temperatures at minimum, 25%, 50%, 75% and 100% load in accordance with ARI 550/590 standard. Data shall be recorded per ARI 500/590 and part load efficiencies calculated.
 - c. The second machine will be tested only at full capacity (1250 tons zero tolerance) at 85F condenser water temperature.
 - d. The chiller shall be capable of operating continuously with condenser water temperatures as low as 65 F and as high as 90.9 F at all range of load conditions. Tripping on safeties, continuous surging, or other failure of the machine at these test conditions shall be considered failure of the factory test.
 - e. At 90.9 F condenser water temperature, full load tonnage shall not be below 1170 tons and efficiency shall be better than 0.650 kw/ton.
 - f. Chiller must meet ASHRAE 90.1 efficiency standards at 85 F condenser water temperatures.
 - g. BNL will select which machine will be the first one tested at the full range of conditions.
 - h. BNL personnel shall witness tests at vendor's facility.
 - i. Failure of chillers to meet capacity or efficiency requirements' is grounds to refuse shipment.
 - j. ARI 550/590 2003 standard shall be used for test procedure.
3. Shaft vibration shall be limited to 1 mil peak-to-peak displacement and a record of shop tests shall be included in Operating and Maintenance Manual.
4. Compressor surging during operation at design conditions will not be permitted.
5. Materials and equipment shall be the products of manufacturers regularly engaged in the manufacture of such products, shall essentially duplicate equipment that has been in satisfactory service prior to issue date of this CONTRACT and shall be supported by a service organization that is reasonably convenient to the site.
6. Chiller shall operate at full scheduled capacity with condenser water temperatures to 90°F. Unit shall be factory tested at condenser water temperatures of 90.9°F and normal operating conditions of 85°F. All capacities and efficiencies shall be provided before acceptance of chiller. The chiller shall start with 65°F condenser water and remain operational at condenser temperatures to 90.9°F.

D. Noise Control Design

1. Equipment noise in this section shall not exceed 90 level in dBA five feet from the unit measured in the free field per applicable standards. A record of shop tests shall be included in Operating and Maintenance Manual.

2. Manufacture must provide a record of a sound test to confirm the design noise level of the specific model and configuration of machine at full load with 85 F condensing water temperatures. Previous test results of the exact machine configuration would be acceptable. If a full load sound test has never been performed on the chiller configuration, a sound test must be performed on one unit. Owner may witness at his option.

1.3 SUBMITTALS

A. Shop Drawings And Product Data

1. Furnish submittals for items that are identified in this SECTION by a different typeface and a bracketed code (e.g., **Item [L]**). Refer to Division 01 Section “Shop Drawings, Product Data and Samples,” for definition of codes for types of submittals and the administrative requirements governing submittal procedure. Additional submittal requirements pertaining to this SECTION are specified herein under this Article.
2. Shop drawings submittals shall bear the CONTRACT DOCUMENTS identifying project name and number, shall be sequentially item numbered. Submit two (2) certified for construction prints and one legibly reproducible copy.
3. Shop drawings submittals shall include clearly delineated verification of compliance with the elements of the CONTRACT DOCUMENTS, including, but not limited, to a manufacturer’s catalog cut and product data, performance data, details of configuration, construction (including machine dimensions and nozzle locations), support, functional ancillary provisions, utilities including power connections, wiring diagrams and sequence of operations, installation details for construction field conditions, vibration amplitude limits for rotating equipment. Performance data shall be certified based upon a computer selection with the specified conditions and utilizing ARI approved computer selection procedures.
4. Submit integrated electrical drawings indicating power, control and instrument wiring interfacing with work under separate contracts for field work as well as factory assembled work. Manufacturer’s electrical drawings are acceptable only when modified and supplemented to exactly reflect CONTRACT conditions. Wiring diagrams shall clearly identify starter interlocks, wiring by the manufacturer and wiring required by others at the project site. Clearly identify items such as pump interlocks, cooling tower interlocks, refrigerant leak detection, proof of flow sensors, system control panels and interfaces with the site monitoring and control system, where applicable. The “system” of drawings shall include: overall schematic (elementary) diagram of the entire system of power circuitry detailing the numbers of wire and conduit sizes, wiring diagrams showing the wiring layout of component assemblies of systems, interconnection wiring diagrams showing terminations of interconnecting conductors between component assemblies, systems, control devices, and control panels with interconnections, sequence of operation for components, assemblies or systems.
5. Include documentation clearly identifying equipment options and auxiliary devices being provided.
6. Furnish recommended spare parts lists for equipment.
7. Identify areas to be insulated; specify materials, thickness, and how to be applied.

B. Certificates

1. *Certificate [C]*: Submit manufacturer’s data report, Form U-1, if subject to ASME code.

C. Guarantee

1. Guarantee [G] the unit to meet the operating conditions, capacity and performance conditions as specified and to remain serviceable for the following specified period. If either the unit or accessories fail to meet operating requirements or if failure of any part occurs during the guarantee period, rework or replace the affected items promptly to meet the CONTRACT requirements at no cost to the OWNER.
2. The OWNER reserves the option to request a performance test throughout the warranty period.
3. If no performance test is made, warranty shall extend for one year from date of initial operation. If a performance test is made, then warranty shall extend one year from date of OWNER'S acceptance of the performance test.
4. If unit fails to meet its guaranteed performance, then warranty shall extend twelve months from date of OWNER'S acceptance of modified unit.
5. Warranty shall include parts and labor replacement for the entire unit for the duration of the guarantee period.
6. Provide an alternate cost for an additional four year warranty for parts and labor.

1.4 OPERATING AND MAINTENANCE DATA

- A. Furnish, per Division 01 Section "Operating and Maintenance Data," installation, operation, lubrication and maintenance instructions and spare parts data manuals for equipment provided under this CONTRACT.
- B. Manuals shall incorporate data to enable operators and maintain personnel to understand the equipment, its potentialities, limitations and maintenance needs. Data on design, construction, installation and operating features shall be included. Data submitted shall exclude content which is not applicable to equipment purchased under this CONTRACT. Manuals shall include the following:
 1. Diagrams (See Shop Drawing requirements).
 2. System OEM components and assembly drawings as built.
 3. Equipment brochures, data and catalog cuts including:
 - a. Performance: Normal and abnormal conditions.
 - b. Installation.
 - c. Operation.
 - d. Trouble-shooting
 - e. Safety precautions.
 - f. Maintenance and repair.
 - g. Nearest authorized representative and stocking spare parts source.
 - h. Recommended spare parts.
 - i. Certified Bid Evaluation Form.

1.5 PERSONNEL INSTRUCTION

- A. Provide, prior to start-up, not less than 8 "classroom" and necessary field training hours for OWNER'S operating and maintenance personnel, upon mutually satisfactory arrangement with OWNER.

1.6 TOOLS

- A. Provide one complete set of special tools as recommended by the manufacturer for field maintenance. Tools shall be contained in a locked toolbox and four keys shall be provided.

PART 2 PRODUCTS

2.1 HERMETIC CENTRIFUGAL WATER CHILLER

A. General

1. *Hermetic centrifugal water chiller [D]*: Packaged assembly, self-contained; including but not limited to motor, centrifugal compressor, condenser, cooler (refrigerant evaporator), main disconnect switch, motor starter(s), microprocessor control center, oil pump, lubrication system, spring vibration isolation, insulation, noise control, accessories, marine water boxes, complete intercomponent piping and wiring ready for minimal field terminal connections, and gage taps necessary for testing and maintenance. Provide lifting lugs conforming to requirements of ASME B30.20-2003 and ASME BTH-1-2005.
2. Units shall be per ARI Standard 550/590, latest edition, with the exception that zero tolerance in capacity will be required, in lieu of the allowable tolerances stated in Standard 550/590 Article 5.6.
3. Refrigerant shall be non-flammable, high thermodynamic efficiency, with lowest direct effect global warming potential, and conforming with ARI and ASHRAE Standards. Acceptable refrigerants are HCFC refrigerant R-123 and HFC refrigerant R-134a. (CFC refrigerants 11, 12 and 500 are not acceptable)
4. Manufacturers:
 - a. Trane.
 - b. Carrier.

B. Compressor Assembly

1. *Compressor Assembly [D]*: Provide single or multi-stage high performance, direct-driven or gear driven, centrifugal type with hermetically sealed compressor-motor assembly. Provide refrigerant cooled motor windings. Multi-stage designs shall include an inter-stage, flash refrigerant economizer.
2. Rotor shall be cast, high strength aluminum, statically and dynamically balanced and tested at least 25% above maximum operating speed. There shall be no critical speed within the operating range of the compressor.
3. Fit shaft with replaceable sleeve-insert type main bearings.
4. Provide a self-contained, forced-feed lubrication system with oil sump, mechanically driven positive displacement lube oil pump, heater, oil cooler, level gauge, thermostatically controlled oil temperature, pressure regulator, and all required filters, strainers, piping, fittings, and control valves. Lubrication system shall supply the proper oil pressure to bearings under all conditions of operation including total loss of power. Provide interlock and differential oil pressure cutout with starting equipment to allow the compressor to operate only when the required oil pressure is available at the bearings. Provide oil pump starter factory mounted and wired.
5. Provide stable operation, modulating capacity control from 100% to 10% of design capacity utilizing multiple radial vane or butterfly damper control and automatic hot gas

bypass if required to maintain stable operation. Control shall include automatic stopping when load falls below 10% capacity point and automatic, unloaded, starting on load demand.

6. Capacity modulation shall be controlled by chilled water leaving temperature. The unit controller shall maintain chilled water leaving temperature to plus or minus 1/2 degF of the set point.
7. Provide compressor discharge line isolation valve.

C. Motors

1. *Motors [D,P]*: Motors shall be high efficiency type. Motors sized 1/2 HP and under shall be rated for 115 VAC power supply and motors sized larger than 1/2 HP shall be rated for 460 Volt, 3 phase, 60 Hz power. Chiller motors are 4160V.
2. Motor speeds shall not exceed 3600 RPM.
3. Prime mover motor enclosure shall be squirrel cage, induction type. Ancillary motors shall be per manufacturer's standard.
4. Provide motor winding RTD's located within each winding or motor casing temperature sensing and connect to the control circuit.
5. Provide reverse phase rotation protection as necessary to preclude damage to any component due to reverse rotation.
6. Provide motor bearing temperature sensing connected to the control circuit.

D. Motor Starter

1. Motor starter: Reduced voltage auto transformer type, 4160V, free standing.
2. NEMA 1 enclosure with lockable hinged doors and electrical lugs for incoming wiring.
3. Starter shall provide stepless compressor motor acceleration.
4. Starter shall include three leg sensing overloads, control transformer for all unit controls, three phase voltage and current readings, ground fault protection, high and low line voltage protection, phase rotation protection, lightning/surge protection, single-phase failure protection, momentary power interruption protection with controlled restart under synchronized conditions, and a non-fused lockable disconnect switch.

E. Refrigerant Condenser

1. *Refrigerant condenser [D]*: Shell-and-tube cleanable type. Provide condenser per ASME Unfired Pressure Vessel Code Section VIII regarding quality of materials used, methods of construction, design of components, and testing of materials, assemblies, connections, and appurtenances.
2. Minimum waterside working pressure shall be 150 PSI and minimum refrigerant side working pressure shall be saturation pressure at 125 degF of refrigerant used. Test vessels, not subject to ASME Code due to size or other limitations, at 1-1/2 times working pressure and full vacuum.
3. Seamless 3/4 inch minimum diameter copper tubing with integral fins, a minimum tube wall thickness of 0.035 inches at the valleys and individually removable from either end of shell. Tubes shall be 0.05-inch tube wall thickness at the plane lands and rolled or provided with a mechanical leak proof seal into the tube sheet. Provide and fit intermediate tube supports to preclude corrosion, vibration, and abrasion.
4. Furnish unit complete with marine type water boxes with separate cover and provision for venting and lifting. Provide vents and drains with valve for each pass. The highest pass

5. Provide heat exchanger tubes individually removable from either end of shell.
6. For connections sized 2-1/2 inches and larger on chilled water and condenser water; provide mechanical grooved couplings as manufactured by Victaulic or Gruvlok and specified elsewhere in these specifications.
7. Provide isolation valve between condenser and evaporator.

F. Cooler (Refrigerant Evaporator)

1. *Cooler [D]*: Shell-and-tube cleanable type. Provide evaporator per ASME Unfired Pressure Vessel Code Section VIII regarding quality of materials used, methods of construction, design of components, and testing of materials, assemblies, connections, and appurtenances.
2. Minimum waterside working pressure shall be 150 PSI and minimum refrigerant side working pressure shall be saturation pressure at 125 degF of refrigerant used. Test vessels, not subject to ASME Code due to size or other limitations, at 1-1/2 times working pressure or 45 psig, whichever is greater and full vacuum.
3. Seamless 3/4 inch minimum diameter copper tubing with integral fins, a minimum tube wall thickness of 0.035 inches at the valleys and individually removable from either end of shell. Tubes shall be 0.05-inch tube wall thickness at the plane lands and rolled or provided with a mechanical leak proof seal into the tube sheet. Provide and fit intermediate tube supports to preclude corrosion, vibration, and abrasion.
4. Design cooler to prevent liquid refrigerant from entering the compressor. Include a suction baffle or mesh eliminator, located above the tube bundle, to prevent refrigerant carry-over to the compressor.
5. Furnish unit complete with marine type water boxes with separate cover and provision for venting and lifting. Provide vents and drains with valve for each pass. The highest pass shall be fitted with a ball valve isolated one inch stainless steel automatic air vent. Evaporator shall be finished with a two part epoxy coating.
6. Provide heat exchanger tubes individually removable from either end of shell.
7. For connections sized 2-1/2 inches and larger on chilled water and condenser water; provide mechanical grooved couplings as manufactured by Victaulic or Gruvlok and specified elsewhere in these specifications.
8. Provide liquid refrigerant line isolation valve.

G. Electrical Requirements

1. Refer to SECTION 15050 "General Mechanical Requirements" for applicable general provisions.
2. Furnish UL Listed electrical components which include one or more control panels provided with: Power and control transformers; combination motor controllers, interlocks, relays, push buttons, pilot lights and other control devices; overload protection devices; audible and visual alarm, intercomponent and interassembly power and control wiring harnessed in bundles to and between terminal blocks per NEC and NEMA requirements. Equipment mounted panels shall be factory furnished and wired to equipment. Provide an installation diagram for interassembly wiring required for field connections.
3. All enclosures shall be NEMA 1 or 12 type, unless otherwise specified.

H. Control System

1. *Control System [D]*: Provide specified control system components and control devices normally furnished for best operation of chiller under specified conditions.
2. Control system shall be completely factory assembled and tested and shall include NEMA 1 control panel and intercomponent piping and wiring ready for minimal field terminal connections.
3. Microelectronics controller shall be provided that will include an alphanumeric display for operator interface with chilling unit with the following minimum information to be transferred through BACnet control interface to WonderWare:
 - a. Date and time of day.
 - b. Operating hours.
 - c. Temperature of water entering condenser.
 - d. Temperature of water leaving condenser.
 - e. Temperature of water entering evaporator.
 - f. Temperature of water leaving evaporator.
 - g. Motor winding temperature.
 - h. Bearing Temperature.
 - i. Refrigerant temperature in condenser.
 - j. Refrigerant temperature in evaporator.
 - k. Refrigerant pressure in condenser.
 - l. Refrigerant pressure in evaporator.
 - m. Differential oil pressure or supply oil pressure.
 - n. Oil temperature.
 - o. Compressor discharge temperature.
 - p. Control Point Settings.
 - q. Number of motor starts.
 - r. Percent full load motor current.
4. Provide a BACnet compatible control interface with RS-485 connection to BACnet network.
5. Provide safety interlocks to protect the machine against starting when damage may occur with improper conditions. These conditions shall include the following list as a minimum:
 - a. Low water flow in condenser.
 - b. Low water flow in evaporator.
 - c. Low oil pressure or low differential oil pressure.
 - d. High oil temperature.
 - e. High motor winding temperature.
 - f. Low evaporator refrigerant temperature.
 - g. High condenser refrigerant pressure.
 - h. High bearing oil temperature.
 - i. High compressor discharge temperature.
 - j. Prolonged surge.
 - k. Power/starter faults
 - 1) Motor over-current.
 - 2) Over voltage.
 - 3) Under voltage.
 - 4) Phase failure.
 - 5) Phase unbalance.

- 6) Phase reversal.
 - 7) Distribution fault.
 - 8) Ground fault.
6. Provide for the following remote functions:
 - a. One contact for all alarm conditions.
 - b. One contact for unit operating status.
 - c. Remote start-stop, except on safety shutdown.
 - d. Remote chilled water temperature reset.
- I. Vibration Control
1. *Vibration control [D]*: Spring type for on-grade location.
 2. *Vibration switch [C]*: Furnish unit complete with manufacturer's standard vibration switch for chiller protection.
- J. Noise
1. Design the chiller(s) to generate a noise level not exceeding 90 dB(A) when measured in accordance with ARI 575. If the chiller noise level exceeds the specified level, wrap all the necessary components, not limited to the motor, compressor, and gearbox, with leaded vinyl, high density, non-wicking fiberglass or solid sheet metal adequate to achieve the specified level.
- K. Insulation
1. *Insulation and Vapor Seal [C,P]*: Insulate and vapor-seal surfaces, which are at 60 degrees F or less surface temperature at normal operating conditions. At a minimum, the evaporator shell, water box and compressor suction line shall be insulated. For areas requiring "burn" protection on hot surfaces, thermal insulate only, vapor seal not required.
 2. Insulation-vapor-seal material shall be non-wicking, cellular elastomer in manufacturer's standard thickness or 3/4 inch, whichever is thicker, to preclude condensation on any surface under site operating conditions.
- L. Refrigerant Relief Valves
1. Provide refrigerant relief valves factory sized and installed on each chiller per ASHRAE Standard 15. For low pressure refrigerant chillers, provide a combination reverse buckling, non-fragmenting rupture disk and resetting relief valve in series. For positive pressure refrigerant chillers, provide redundant, resetting relief valves in lieu of the rupture disk and resetting relief valve.
 2. Provide a refrigerant leak detection monitor pick-up point on the relief valve discharge line.
- M. Refrigerant And Oil Charge
1. Provide a complete initial charge of refrigerant and oil and make-up any losses resulting from faulty manufacture or malfunction of equipment during the length of the warranty.
 2. Each unit shall be tested for leaks under pressure and shall be evacuated and dehydrated to 35 degF wet bulb or an absolute pressure of not over 0.15 inch of mercury.

N. Painting And Protection

1. Prime and finish paint uninsulated surfaces using manufacturer's standard paint. Fit openings with suitable protective covers prior to shipping.

2.2 REFRIGERANT LEAK DETECTION

A. Refrigerant Leak Detection And Alarm

1. *Refrigerant leak detection monitor [D]*: Refrigerant leak detection monitor system: Provide a refrigerant leak detection system of the continuous monitoring type for each mechanical equipment room where refrigeration equipment will be located. Detection system shall be compatible with the specific refrigerants to be present in the cooling equipment and shall comply with the requirements of ASHRAE Standard 15. Locate detector sensing pick-up points a maximum of 18 inches above the floor. Upon detection of a refrigerant leak, the system shall indicate an audible and visible alarm and start the equipment room "emergency ventilation" exhaust. System shall be 120 VAC, single phase, 60 Hz and be U.L listed.

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

A. Check, Test And Start-Up

1. Provide all labor and materials for equipment check out and testing by a factory trained and authorized representative of the refrigeration machine manufacturer prior to starting the machine. Upon successful check out and testing, machine shall be started by the manufacturer's Service Technician. The report of check, test and start-up shall be documented and certified in writing on the manufacturer's standard forms.

B. Installation And Run-In

1. Installation and related work shall be performed under the direction of an authorized representative of the manufacturer.
2. Start-up and run-in shall be performed under the direction of an authorized representative of the manufacturer who shall inspect, make critical adjustments of equipment and calibration of controls, to verify a complete, properly functioning installation with capacity as scheduled.

C. Field Start-Up Vibration Test

1. At time of start-up, the manufacturer's qualified, authorized representative shall test with a certified calibrated vibrometer, readable to 0.0001 inch displacement, prime mover related rotating machinery to deliver to OWNER, two copies of readings taken in the presence of the OWNER'S REPRESENTATIVE.
2. Readings shall be taken at steady state conditions under 100%, 75%, 50%, 25%, 10%, 5% and zero loads, as well as under transient load change conditions.
3. Reading shall be compared with those of factory shop tests.

D. Field Tests During Guarantee Period

1. General

- a. Testing to determine compliance with requirements of CONTRACT DOCUMENTS shall be performed per the following:
 - 1) Testing procedures for items not delineated in CONTRACT DOCUMENTS, shall be mutually agreed upon, in writing, prior to start of testing.
 - 2) Test procedure participant's costs shall be borne by:
 - a) The OWNER if compliance is verified.
 - b) The CONTRACTOR if testing indicates failure to comply.
- b. Testing will be performed in the presence of the OWNER'S REPRESENTATIVE.
- c. If the testing or retesting of the unit furnished under this CONTRACT should indicate failure to meet the requirements of the CONTRACT DOCUMENTS, the CONTRACTOR shall be responsible for whatever additions, modifications or replacements may be necessary to provide the OWNER with a unit which fully conforms to these performance requirements. Repair work shall be scheduled at a time convenient to the facility being served.

2. Equipment Vibration

- a. In the event that OWNER determines that testing is required, specified limits of vibration shall be verified under operating conditions by an independent equipment and testing source such as Entek IRD.

3. Performance Testing

- a. In the event that OWNER determines that testing is required, the test procedures of the ARI Standard 550 shall be utilized.

END OF SECTION

Revision History	
Date	Rev. No.
A	0
B	0
C	0
D	0
E	0
F	0
02-19-09	0

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