

SECTION 23 64 00
PACKAGED WATER CHILLERS**PART 1 - GENERAL****1.1 DESCRIPTION**

Centrifugal water-cooled chillers, complete with accessories.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- D. Section 23 21 23, HYDRONIC PUMPS.
- E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- F. Section 23 21 13, HYDRONIC PIPING.
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- H. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- I. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 DEFINITION

- A. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.
- B. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
- C. FTT-10: Echelon Transmitter-Free Topology Transceiver.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, and comply with the following.
- B. Refer to PART 3 herein after and Section 01 00 00, GENERAL REQUIREMENTS for test performance.
- C. Comply with AHRI requirements for testing and certification of the chillers.
- D. Refer to OSHA 29 CFR 1910.95(a) and (b) for Occupational Noise Exposure Standard.
- E. Refer to ASHRAE Standard 15, Safety Standard for Refrigeration System, for refrigerant vapor detectors and monitor.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
- 370-01.....Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
 - 495-1999 (R2002).....Refrigerant Liquid Receivers
 - 550/590-03.....Standard for Water Chilling Packages Using the Vapor Compression Cycle
 - 560-00.....Absorption Water Chilling and Water Heating Packages
 - 575-94.....Methods for Measuring Machinery Sound within Equipment Space
- C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
- ANSI/ASHRAE 15-2007.....Safety Standard for Mechanical Refrigeration Systems
 - GDL 3-1996.....Guidelines for Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems
- D. American Society of Mechanical Engineers (ASME):
- 2007ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels - Division 1"
- E. American Society of Testing Materials (ASTM):
- C 534/ C 534M-2008.....Preformed, Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 - C 612-04.....Mineral-fiber Block and Board Thermal Insulation
- F. National Electrical Manufacturing Association (NEMA):
- 250-2008.....Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. National Fire Protection Association (NFPA):
- 70-2008.....National Electrical Code
- H. Underwriters Laboratories, Inc. (UL):
- 1995-2005..... Heating and Cooling Equipment

1.6 SUBMITTALS

- A. Submit in accordance with Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data.
 - 1. Centrifugal water chillers, including motor starters, control panels, and vibration isolators, evaporator and condenser data shall include the following:
 - a. Rated capacity.
 - b. Pressure drop.
 - c. Number of tubes.
 - d. Efficiency at full load (COP) and part load (1PLV) WITHOUT applying any tolerance indicated in the AHRI 550/590/Standard.
 - e. Refrigerant
 - f. Accessories.
 - g. Installation instructions.
 - h. Start up procedures.
 - i. Wiring diagrams, including factor-installed and field-installed wiring.
 - j. Sound/Noise data report. Manufacturer shall provide sound ratings. Noise warning labels shall be posted on equipment.
 - k. Refrigerant vapor detectors and monitors.
- C. Maintenance and operating manuals for each piece of equipment in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- D. Run test report for all chillers.
- E. Product Certificate: Signed by chiller manufacturer certifying that chillers furnished comply with AHRI requirements. The test report shall include calibrated curves, calibration records, and data sheets for the instrumentation used in factory tests.

PART 2 - PRODUCTS**2.1 CENTRIFUGAL WATER-COOLED WATER CHILLERS**

- A. General: Chiller shall be factor-assembled and-tested, complete with evaporator, condenser, compressor, motor, variable frequency drive, oil heater and cooler, economizer or intercooler, purge system (if required), refrigerant piping, instrumentation and control piping, operating and safety controls mounted on the chiller, and other auxiliaries necessary for safe and proper operation of the unit. Chiller operation shall be fully automatic.

- B. Performance: Provide the capacity as shown on the drawings. Part load and full load efficiency ratings of the chiller shall not exceed those shown on the drawings.
- C. Capacity of a single water-cooled chiller shall not exceed 1,250 Tons (Standard AHRI Conditions).
- D. Applicable Standard: Chillers shall be rated and certified in accordance with AHRI Standard 550/590. Chillers shall be AHRI stamped. Chiller efficiency shall comply with FEMP (Federal Energy Management Progress) requirements.
- E. Acoustics: Sound pressure levels shall not exceed the following specified levels. The manufacturer shall provide sound treatment if required to comply with the specified maximum levels. Testing shall be in accordance with AHRI 575.

OCTAVE BAND								Overall
<u>63</u>	<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>4000</u>	<u>8000</u>	<u>dB(A)</u>
75	78	76	76	75	77	72	67	81

- F. Hermetic or open: Chillers shall be open or hermetically sealed, using HFC-134a refrigerant OR R-123 refrigerant.
- G. Compressor (Centrifugal Type): Single, having statically and dynamically balanced impeller, gear driven. Impeller shaft shall be heat-treated carbon steel of sufficient rigidity to prevent whip or vibration at operating speed. Shaft main bearings shall be of journal type with bronze or babbitt line steel cartridge, aluminum alloy one-piece insert type, or rolling element type with an AFBMA L 10 life of a minimum of 200,000 hours. Rolling element bearings shall be rated in accordance with AFBMA 9 or AFBMA 11 as applicable. Casing shall be cast iron or steel plate with split sections gasketed and bolted together. Lubrication System shall be force-feed type and shall provide oil at proper temperature to all parts requiring lubrication. Make provisions to insure lubrication of bearings prior to starting and of shaft seal both on stopping and starting, or bearings and shaft seal shall be submerged in oil. On units providing for force-feed lubrication prior to starting, a differential oil pressure cutout interlocked with compressor starting equipment shall allow compressor to operate only when required oil pressure is provided to bearings. Capacity control shall be by means of remote mounted variable speed

drive to modulate the chiller capacity from 100 to 10 percent of full unit rated capacity without unstable compressor operation.

- H. Evaporator: Shell-and-tube type, constructed and tested and stamped in accordance with Section VIII D1 of ASME Boiler and Pressure Vessel Code where applicable for working pressure produced by refrigerant used and water system installed, but not less than 1035 kPa (150 psig) waterside working pressure. Shell shall be fabricated of carbon steel and shall have carbon steel tube sheets; drilled and reamed to accommodate the tubes. Tubes shall be externally and internally enhanced individually replaceable and shall be expanded full diameter into tube sheets, providing a leak proof seal. Intermediate tube supports sheets shall be provided as recommended by the manufacturer to minimize tube vibration, stress, and wear. Performance shall be based on a water velocity not less than 1 m/s (3 fps) nor more than 4 m/s (12 fps), and fouling factor of 0.0000176 m² degrees C (0.0001 hr. sq.ft. degrees F/Btu). Design working pressure shall be 1035 kPa (150 psig); pressure tested at 130 percent of working pressure. Water nozzle connections shall be flanged.
- I. Condenser: Shell-and-tube type, constructed, tested, and stamped in accordance with applicable portions of Section VIII D1 of the ASME Boiler and Pressure Vessel Code, where applicable for working pressure produced by the refrigerant used and water system installed, but not less than 1035 kPa (150 psig). Shell shall be fabricated of carbon steel and shall have carbon steel tube sheets; drilled and reamed to accommodate the tubes. Tubes shall be nonferrous metal, externally enhanced, and internally enhanced, individually replaceable, and shall be expanded full diameter into tube sheets, providing a leak proof seal. Intermediate tube support sheets shall be provided as recommended by the manufacturer to minimize tube vibration, stress and wear. Tubes shall fit tightly in the supports to prevent chafing due to vibration or pulsation. Performance of condenser shall be based on a water velocity not less than 1 m/s (3 fps) nor more than 4 m/s (12 fps), and a fouling factor of 0.000044 m² degrees C (0.00025 hr. sq. ft.) degrees F/Btu. Design working pressure shall be 1035 kPa (150 psig) 2070 kPa (300 psig); pressure tested at 130 percent of working pressure. Water nozzle connections shall be flanged.
- J. Insulation: Evaporator, suction piping, compressor, and all other parts subject to condensation shall be insulated with 40 mm (1.5 inch)

minimum thickness of flexible-elastomeric thermal insulation, complying with ASTM C534.

- K. Motor Load Limiter: Provide a sensing and control system, which will limit maximum load current of compressor motor to a manually selectable percentage of 40 percent to 100 percent of full load current. System shall sense compressor motor current and limit it by modulating inlet guide vanes at the compressor, overriding other controls in their ability to increase loading, but not overriding their ability to reduce loading.
- L. Purge System: Chillers utilizing HCFC-123 shall be supplied with Purge System. Purge unit shall be factory-mounted, complete with necessary, piping, operating, and safety controls and refrigerant service valves to isolate the unit from the chilling unit. Purge unit shall be air, water, or refrigerant cooled. When in operation, purge system shall function automatically to remove, water vapor, and condensable gases from refrigeration system and to condense, separate, and return to system any refrigerant present therein. Purge system shall be manually or automatically started and stopped, and shall be assembled as a compact unit. As an option, a fully automatic purge system that operates continuously while main unit is operating may be furnished. Such purge system shall provide a means to signal operator of occurrence of excessive purging indicating abnormal air leakage into unit. The purge system shall be of high efficiency in recapturing the refrigerant at all load and head conditions and with capability to operate when the chiller is off. The purge unit shall be UL listed.
- M. Isolators: Per Specification Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- N. Refrigerant and Oil:
1. Provide sufficient volume of dehydrated refrigerant and lubricating oil to permit maximum unit capacity operation before and during tests. Refrigerant charge lost during the warranty period due to equipment failure shall be replaced without cost to the Government.
 2. The manufacturer shall certify that chiller components, such as seals, o-ring, motor windings, etc, are fully compatible with the specified refrigerants.
- O. Chillers utilizing HCFC-123 shall be supplied with a vacuum prevention system to maintain the chiller at positive pressure during non-operational cycles.

- P. Chillers utilizing HCFC-123 shall be supplied with frangible carbon rupture disc, all metal, non-fragmented with reverse buckling design rupture disc, and a safety relief valve downstream of the rupture disc. Chillers using refrigerants HFC-134a shall be supplied with single or multiple reseating type, spring-loaded relief valve .
- Q. Service valves shall be provided to facilitate refrigerant reclaim/removal required during maintenance.
- R. Chillers using refrigerants HFC-134a shall be supplied with single or multiple reseating type, spring-loaded relief valve.
- S. Service valves shall be provided to facilitate refrigerant reclaim/removal required during maintenance.
- T. Controls: Chiller shall be furnished with unit mounted, stand-alone, microprocessor-based controls in NEMA 1 enclosure, hinged and lockable, factory wired with a single point power connection and separate control circuit. The control panel provide chiller operation, including monitoring of sensors and actuators, and shall be furnished with light emitting diodes or liquid-crystal display keypad.
1. Following functions shall display as a minimum:
 - a. Date and Time.
 - b. Outdoor air temperature.
 - c. Operating set point temperature and pressure.
 - d. Operating hours.
 - e. Operating or alarm status.
 - f. Chilled water temperature-entering and leaving.
 - g. Condenser water temperature-entering and leaving.
 - h. Refrigerant pressure-condenser and evaporator.
 - i. Low oil pump pressure.
 - j. High oil supply pressure.
 - k. Chiller diagnostic codes.
 - l. Current limit set point.
 - m. Number of compressor starts.
 2. Control Functions:
 - a. Control set points for entering and leaving chilled temperatures.
 - b. Condenser water temperature.
 - c. Current/demand limit.
 - d. Motor load limit.
 3. Safety Controls: Following conditions shall shut down the chiller and require manual reset to start:

- a. High condenser pressure.
 - b. High oil temperature.
 - c. High or low oil pressure.
 - d. Loss of flow-condenser or chilled water.
 - e. Low chilled water temperature.
 - f. Low evaporator refrigerant temperature.
 - g. Sensor malfunctions.
 - h. Power fault.
 - i. Extended compressor surge.
 - j. Communication loss between the chiller and its control panel. A signal must be transmitted to Energy Control Center, if provided, for this communication loss and for any abnormal.
4. Leaving chilled water temperature reset, where specified in the control sequence, shall be based on 4-20 MA or 0-10 VDC signal from a building automation system.
 5. Chillers shall be pre-wired to terminal strips for interlocked to other equipment.
 6. Provide contacts for remote start/stop, alarm for abnormal operation or shut down, and for Engineering Control Center (ECC) interface.
 7. Chiller control panel shall reside on the "LON network", and provide data using open protocol network variable types and configuration properties.
 8. Auxiliary hydronic system and the chiller(s) shall be electronically interlocked to provide time delay and starting sequence as indicated on control drawings.
 9. The chiller control panel shall utilize the following components to automatically take action to prevent unit shutdown due to abnormal operating conditions which will perform as follows.
 - a. High pressure switch that is set to 20 psig (adjustable setting) lower than factory pressure switch that will automatically unload the compressor to help prevent a high pressure condenser control trip. One switch is required for each compressor and indicating light shall also be provided.
 - b. Motor surge pressure that is set at 95% of compressor RLA that will automatically unload the compressor to prevent an over current trip. One protector is required for each compressor and indicating light shall also be provided.

- c. Low pressure switch that is set at 5 PSIG above the factory low pressure switch that will automatically unload the compressor to help prevent a low evaporator temperature trip. One switch is required for each compressor and indicating light shall also be provided.
 - d. In all the above cases, the chiller will continue to run, in an unloaded state and will continue to produce some chilled water in an attempt to meet the cooling load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset is required. Once the "near trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.
- 10. With variation of +/-10% of design flow per minute, chiller shall be able to maintain +/-0.5 degrees F leaving water temperature control. The chiller must be able to withstand a +/- 30% change in flow rate per minute without unit trip. Variations in the primary flow allow for optimal system efficiency, but the chiller must be able to maintain temperature control to help ensure occupant comfort.
 - 11. The chiller control panel shall provide +/-0.5 degrees F leaving water temperature control during normal operation. The chiller shall provide multiple steps leaving chilled water temperature controller to minimize part load energy use and optimize leaving chilled water temperature control.
 - 12. The chiller control panel shall provide a 2-minute stop-to-start and 5 minute start-to-start solid state timer. If the anti-recycle timers are longer than 5 minutes, then hot-gas bypass shall be provided to limit loss of leaving chilled water temperature control in low-load conditions.
- U. Motor: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Compressor motor furnished with the chiller shall be in accordance with the chiller manufacturer and the electrical specification Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT. Starting torque of the motor shall be suitable for the driven chiller machine.
- V. Compressor Motor Starter
- 1. The Variable Speed Drive will be remote floor mounted. It will vary the compressor motor speed by controlling the frequency and voltage

- of the electrical power to the motor. The adaptive capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part-load efficiency by analyzing information fed to it by sensors located throughout the chiller.
2. Drive will be PWM type utilizing IGBTs with a power factor of 0.95 or better at all loads and speeds.
 3. The variable speed drive will contain two control power transformers, a 115V single phase nominal 2.0KVA transformer will be supplied for the Dynamic flat panel touchscreen interactive display Control Center and a 460v three phase 60Hz up to 3KVA transformer will be supplied for chiller oil pump operation.
 4. The following features will be provided:
 - a. Door interlocked circuit breaker capable of being padlocked.
 - b. UL listed ground fault protection.
 - c. Over voltage and under voltage protection.
 - d. 3-phase sensing motor over current protection.
 - e. Single phase protection.
 - f. Insensitive to phase rotation.
 - g. Over temperature protection.
 - h. Digital readout at the chiller unit control panel of output frequency, output voltage, 3-phase output current, input Kilowatts and Kilowatt-hours, self-diagnostic service parameters. Separate meters for this information will not be acceptable.
 - i. KW Meter - The unit's input power consumption will be measured and displayed digitally via the unit's control panel. The KW meter accuracy shall be +/- 3% of reading. KW meter scale is 0 - 1000 KW.
 - j. KWh Meter - The unit's cumulative input power consumption is measured and displayed digitally via the unit's control panel. The KWh meter is resettable and its accuracy shall be +/- 3% of reading. KWh meter scale is 0 - 999,999 kWh.
 - k. Ammeter - Simultaneous three-phase true RMS digital readout via the unit control panel. Three current transformers provide isolated sensing. The ammeter accuracy shall be +/- 3% of reading. Ammeter scale is 0 - 545 A RMS.
 - l. Voltmeter - Simultaneous three-phase true RMS digital readout via the unit control panel. The voltmeter accuracy shall be +/- 3% of reading. Voltmeter scale is 0 - 670 VAC.
 - m. Elapsed Time Meter - Digital readout of the unit's elapsed running time (0 - 876,600 hours, resettable) is displayed via the unit control panel.

5. A 24 pulse input transformer filter that limits electrical power supply distortion for the variable speed drive to comply with the guidelines of IEEE Std. 519-1992 will be provided. The transformer will be mounted within the same NEMA-1 enclosure and will be UL listed. The following digital readouts shall be provided at the chiller unit control panel as part of the package; input KVA, total power factor, 3 phase input voltage, 3 phase input current, self diagnostic service parameters. Separate meters for this information will not be acceptable.
6. Variable Frequency Drive shall be engineered and manufactured by the chiller manufacturer specifically for use with the chiller it is driving. Technician performing chiller startup shall be trained and factory certified to perform the VFD startup in conjunction with the chiller startup.

2.2 REFRIGERANT MONITORING AND SAFETY EQUIPMENT

- A. General: Provide refrigerant monitoring sensor/alarm system and safety equipment as specified here. Refrigerant sensor and alarm system shall comply with ASHRAE Standard 15. The refrigerant monitoring system will be provided by the chiller manufacturer and shall be interfaced with the DDC control system.
- B. Refrigerant monitor shall continuously display the specific gas (refrigerant used) concentration; shall be capable of indicating, alarming and shutting down equipment; and automatically activating ventilation system. On leak detection by refrigerant sensor(s), the following shall occur:
 1. Activate machinery (chiller) room ventilation.
 2. Activate visual and audio alarm inside and outside of machinery room, with beacon light(s) and horn sounds equipment room and outside equipment room door(s). Shut down combustion process where combustion equipment is employed in the machinery room.
 3. Notify Engineering Control Center (ECC) of the alarm condition.
- C. Refrigerant monitor shall be capable of detecting concentration of 1 part per million (ppm) for low-level detection and for insuring the safety of operators. It shall be supplied factory-calibrated for the refrigerant supplied with the chiller and R-123.
- D. Monitor design and construction shall be compatible with temperature, humidity, barometric pressure, and voltage fluctuations of the machinery room operating environment.

PART 3 - EXECUTION

3.1 EXAMINATION

Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping and electrical to verify actual locations and sizes

before chiller installation and other conditions that might affect chiller performance, maintenance, and operation. Equipment locations shown on drawings are approximate. Determine exact locations before proceeding with installation.

3.2 EQUIPMENT INSTALLATION

- A. Install chiller on concrete base with isolation pads.
 - 1. Concrete base is specified in Section 03 30 00, CAST-IN-PLACE CONCRETE
 - 2. Vibration isolator types and installation requirements are specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT
 - 3. Anchor chiller to concrete base according to manufacturer's written instructions and for seismic restraint on vibration isolators.
 - 4. Charge the chiller with refrigerant, if not factory charged.
 - 5. Install accessories and any other equipment furnished loose by the manufacturer, including remote starter, remote control panel, and remote flow switches, according to the manufacturer written instructions and electrical requirements.
 - 6. Chillers shall be installed in a manner as to provide easy access for tube pull and removal of compressor and motors etc.
- B. Install refrigerant monitoring and safety equipment in accordance with ASHRAE Standard 15.
- C. Install thermometers and gages as recommended by the manufacturer and/or as shown on drawings.
- D. Piping Connections:
 - 1. Make piping connections to the chiller for chilled water, condenser water, and other connections as necessary for proper operation and maintenance of the equipment.
 - 2. Make equipment connections with flanges and couplings for easy removal and replacement of equipment from the equipment room.
 - 3. Extend vent piping from the relief valve rupture disk and purge system to the outside.

3.3 STARTUP AND TESTING

- A. Engage manufacturer's factory-trained representative to perform startup and testing service.
- B. Inspect, equipment installation, including field-assembled components, and piping and electrical connections.

- C. After complete installation startup checks, according to the manufacturers written instructions, do the following to demonstrate to the VA that the equipment operate and perform as intended.
1. Check refrigerant charge is sufficient and chiller has been tested for refrigerant leak.
 2. Check bearing lubrication and oil levels.
 3. Verify proper motor rotation.
 4. Verify pumps associated with chillers are installed and operational.
 5. Verify thermometers and gages are installed.
 6. Verify purge system, if installed, is functional and relief piping is routed outdoor.
 7. Operate chiller for run-in-period in accordance with the manufacturer's instruction and observe its performance.
 8. Check and record refrigerant pressure, water flow, water temperature, and power consumption of the chiller.
 9. Test and adjust all controls and safeties. Replace or correct all malfunctioning controls, safeties, and equipment as soon as possible to avoid any delay in the use of the equipment.
 10. Prepare a written report outlining the results of tests and inspections, and submit it to the VA.
- D. Engage manufacturer's certified factory trained representative to provide training for 16 hours for the VA maintenance and operational personnel to adjust, operate and maintain equipment, including self-contained breathing apparatus.

3.4 FACTORY TESTING

- A. Prior to shipping the chiller, manufacturer shall perform the following factory witness testing:
1. A factory performance test will be performed in accordance with the most recent ARI Standard. The ARI Factory Performance Test shall begin with a start of the chiller at minimum its capacity with the Manufacturer's proposed Lowest Entering Condenser water Temperature @3750 gpm, and demonstrate stable operation for eight continuous hours, then proceed to 20%, 30%, and 50% capacity, with the Manufacturer's stated Lowest Entering Condenser water Temperature @3750 gpm, and complete the ARI Test at 100% capacity with 85°F entering condenser water (@3750 gpm). This is a test to demonstrate submitted unit performance.

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