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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2009

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SECTION 42 22 16

RECIPROCATING PROCESS CHILLERS AND COOLERS 08/08

NOTE: This specification covers the requirements for water cooled reciprocating water chillers for refrigerating and air conditioning applications.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically
be deleted from this section of the project
specification when you choose to reconcile
references in the publish print process.

The publications listed below form a part of this specification to the
extent referenced. The publications are referred to within the text by the
basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 550/590 (2003) Standard for Water-Chilling
Packages Using the Vapor Compression Cycle

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE EQUIP IP HDBK (2004) Handbook, HVAC Systems and
Equipment (IP Edition)

ASHRAE EQUIP SI HDBK (2004) Handbook, HVAC Systems and
Equipment (SI Edition)

ASHRAE HVAC APP SI HDBK (2007) HVAC Applications Handbook, SI
Edition

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (2003; Corrigendum 2005) Mechanical
Vibration - Balance Quality Requirements
for Rotors in a Constant (Rigid) State -
Part 1: Specification and Verification of
Balance Tolerance - International
Restrictions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2007; Errata 2008) Standard for Motors
and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2008; AMD 1 2008) National Electrical
Code - 2008 Edition

U.S. DEPARTMENT OF ENERGY (DOE)

DOE CE-6 (2000) How to Buy an Energy-Efficient
Air-Cooled Electric Chiller

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions
in Section 01 33 00 SUBMITTAL PROCEDURES and edit
the following list to reflect only the submittals
required for the project. Keep submittals to the

minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Submit connection diagrams indicating the relations and connections of the following items. The drawings shall indicate the general physical layout of all controls, and internal tubing and wiring details.

Compressor
Motor
Control Panel
Condenser
Evaporator
Refrigerant Circuit
Alarm Systems
Vibration Isolators
Gages

Submit [Control Diagrams](#) for water-cooled reciprocating chiller units in accordance with paragraph entitled, "Control," of this section.

SD-03 Product Data

Submit Equipment and Performance Data for the following items indicating use life, system functional flows, safety features, and other features such as electrical system protective device ratings.

Chiller Unit
Compressor
Condenser

Submit manufacturer's catalog data for the following items:

Accessories
Spare Parts
Vibration Isolators

SD-07 Certificates

Submit certificates for following items showing conformance with the referenced standards contained in this section.

Compressor
Motor
Control Panel
Condenser
Evaporator
Refrigerant Circuit
Alarm Systems
Vibration Isolators
Gages

SD-08 Manufacturer's Instructions

Submit [Manufacturer's Instructions](#) for water-cooled reciprocating chiller units in accordance with paragraph entitled, "General Requirements," of this section.

SD-10 Operation and Maintenance Data

Submit [Operation and Maintenance Manuals](#) in accordance with paragraph entitled, "Manufacturer's Field Service," of this section.

1.3 GENERAL REQUIREMENTS

Submit [Manufacturer's Instructions](#) for water-cooled reciprocating chiller units including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

1.3.1 Mechanical

NOTE: If Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted

and the second paragraph deleted.

[Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS applies to work specified in this section.]

[Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work specified in this section.]

1.3.2 Electrical

Rate motors in accordance with Section 26 60 13.00 40 LOW-VOLTAGE MOTORS.

Provide solid state sensors and protection in accordance with Section 26 05 70.00 40 HIGH-VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW-VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

PART 2 PRODUCTS

NOTE: Compressor and motor balance shall conform to ISO Std. 1940/1 - (1986) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA Specification MG-1, Motors and Generators, Part 7 unless otherwise noted.

2.1 MANUFACTURED CHILLER UNIT

NOTE: For descriptive specification, edit this article to suit project conditions. If performance specification is used for the project, delete this article.

Provide factory assembled water cooled liquid chiller unit, consisting of [two] [_____] [semi-] hermetic reciprocating, motor-driven compressor[s] mounted on [spring] [_____] vibration isolators, [hot gas muffler,] condenser, insulated evaporator, [independent refrigerant circuits,] thermal expansion valves, refrigeration accessories, and control panels.

Except as specified, ensure unit and spare parts are the manufacturer's standard product, designed for the service indicated, and tested and rated in accordance with AHRI 550/590.

Factory run-test(s) prior to shipment, with capacity, current draw, and control operation monitored, recorded, and submitted. Ship unit(s) with a full operating charge of [R-22] or other suitable refrigerant with ODP=0.0, and oil. Operate the unit with [230] [208] [480] volt 3-phase, 60 Hertz power.

"Energy efficiency ratings shall meet or exceed the full-load efficiency and the integrated part-load value (IPLV) efficiency ratings as described in ARI Standard 550/590-98 and DOE CE-6."

2.2 LIQUID CHILLER

NOTE: Performance specification for one, or identical units. Use schedule to specify units of different sizes.

Reciprocating water chiller unit shall have minimum capacity of [_____] **watt tons of refrigeration** when delivering [_____] **cubic meter per second gpm** of chilled water at [_____] **degrees C degrees F** when supplied with [_____] **cubic meter per second gpm** of condenser water at [_____] **cubic meter per second [_____] degrees F**. For determining this capacity, ensure the fouling factor for evaporator and condenser is no less than 0.0005. Water head loss shall not exceed [_____] **millimeter [_____] feet** through condenser, or [_____] **millimeter [_____] feet** through evaporator.

2.3 COMPONENTS

NOTE: The following article may be deleted, or edited as necessary to suit project conditions and to further describe the Manufactured Chiller Unit.

2.3.1 Compressor

Construct the compressor(s) with heat treated [forged steel] [ductile iron] crankshafts, aluminum alloy connecting rods, cast aluminum pistons fitted with one compression ring and one oil ring, replaceable cylinder liners, and double mesh suction inlet screens. Housing, cylinder heads, liners, and handhole covers shall be close grain cast iron. Suction and discharge valves shall be high strength, non-flexing, ring type. Valve plates shall be of cast iron, with ground and lapped seats. Rotating parts shall be statically and dynamically balanced to **ISO 1940-1-1986**, [G16] [G6.3] [_____] . Mount compressors on [spring] [_____] vibration isolators. Provide isolation service valves on inlet and outlet lines of each compressor.

2.3.1.1 Lubricating System

Provide lubricating system with positive displacement oil pump, oil charging valve, oil level sight glass, oil filter, and magnetic-plug on strainer, arranged to be self relieving to the suction side, and to ensure adequate lubrication during starting, stopping, and normal operation.

2.3.1.2 Capacity-Reduction

Provide automatic capacity-reduction equipment consisting of suction valve unloaders. Operate the lifting mechanism by [oil pressure] [gas discharge pressure] [solenoid valve]. Provide for unloaded compressor start.

2.3.1.3 Motor

Compressor shall conform to **NEMA MG 1**, be direct-driven by [1800] [3600] rpm, [230] [_____] volt, 3-phase, 60 Hertz, constant speed motor, UL listed, and designed for [across-the-line] [part-winding] [_____] starting. Motor shall have copper windings and be suction gas cooled. Provide solid state sensor and electronic winding overheating protection.

2.3.1.4 Crankcase Heater

Crankcase heater shall be immersible type. Energize heater [continuously] [_____]. [Mount a "DANGER - EXTERNAL POWER SUPPLY" sign having 10 millimeter 3/8-inch white letters with red background on the junction box for the crankcase heater.]

2.3.2 Condenser

Condenser shall be shell-and-tube type, of [seamless] [welded] steel construction, with removable [cast iron] [fabricated steel] heads [and independent, dual refrigerant circuits].

Tubes shall be cleanable [and] [replaceable] [seamless copper] [_____], with integral fins, [expanded] [_____] into tube sheets.

Design, test, and stamp refrigerant side for [2050] kilopascal [300] psig [_____] working pressure in accordance with ASHRAE HVAC APP SI HDBK and ASHRAE EQUIP SI HDBK ASHRAE EQUIP IP HDBK, Chapter 13.

Provide [2050] kilopascal [300] psig [_____] safety relief valve on condenser shell.

Design, test, and stamp water side for [1030] kilopascal [150] psig [_____] working pressure in accordance with ASHRAE HVAC APP SI HDBK and ASHRAE EQUIP SI HDBK ASHRAE EQUIP IP HDBK, Chapter 13. Provide drain connection.

2.3.3 Evaporator

Evaporator shall be shell-and-tube type, of [seamless] [welded] steel construction, with removable [cast iron] [fabricated steel] heads [and independent, dual refrigerant circuits].

Tubes shall be cleanable [and] [replaceable] [seamless copper] [_____], with integral fins, [expanded] [_____] into tube sheets.

Design, test, and stamp refrigerant side for [1550] kilopascal [225] psig [_____] working pressure, and water side for [1030] kilopascal [150] psig [_____] working pressure, in accordance with ASHRAE HVAC APP SI HDBK and ASHRAE EQUIP SI HDBK ASHRAE EQUIP IP HDBK, Chapter 13. Provide water drain connection.

Insulate with [_____] [25] millimeter [_____] [100] inch thick flexible [expanded polyvinyl chloride] [polyurethane foam] insulation with maximum K value of [0.037] watt per meter per degree Kelvin [0.26] Btu per hour per foot square per degree F [_____].

2.4 ACCESSORIES

2.4.1 Refrigerant Circuit

Each independent refrigerant circuit shall be factory supplied and piped, and complete with liquid line solenoid valve, filter dryer, liquid line sight glass and moisture indicator, thermal expansion valve, [charging valve][8 millimeter 1/4-inch flare charging ports], insulated suction line, compressor discharge service valve, [discharge line check valve.]

2.4.2 Control

Submit **Control Diagrams** for water-cooled reciprocating chiller units showing the physical and functional relationship of equipment. Electrical diagrams shall show size, type, and capacity of the systems.

Power and control devices, including but not limited to motor starters, relays, timers, fuses, circuit breakers, shall be in accordance with Section 26 05 70.00 40 HIGH-VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW-VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

Components of the control panel, and external control devices, shall be UL listed. Designate all components with a code, and called out by that code on the wiring diagrams and schematics.

Timers shall be electronic, with adjustable settings. Indicating lights shall be push-to-test type and easily replaceable from the front of the panel.

2.4.2.1 Sequence Panel

**NOTE: Include this paragraph only if multiple units
are provided.**

Provide a [remote mounted] sequence panel, with sequence switch, temperature controller, and low temperature cutout, to permit operation in [series] [parallel] with lead-lag switching.

2.4.2.2 Control Panel

Control panel, having separate sections for starter and refrigeration controls, shall be furnished for each compressor and located [on] [near] chiller unit. Starter section shall have internal access door and customer connection junction box with knockouts for remote interlocks.

Ensure control panels are factory assembled, and wired in accordance with UL and NFPA 70 requirements, with single point power connection. Identify each wire at every termination with a wire number matching the wiring diagram and control schematic. Wire identification shall utilize preprinted heat-shrink wire sleeves. Hand lettering or marking is not acceptable.

For each control panel, the starter section shall have:

Circuit breaker type combination starter.

Power controls for [across-the-line] [part winding] [_____] starting.

Control power [fuse] [circuit breaker].

Control power transformer for [115] [_____] -volt control voltage.

Terminal blocks, having terminals for the main power supply and all auxiliary connections clearly identified.

Pumpdown control relay.

Compressor starter relay.

Reset relay.

Non-recycling compressor overload relay.

Anti-recycle timer.

For each control panel, the refrigeration section shall have:

High pressure control.

Low pressure control.

Motor protection.

Oil pressure control.

Mount the following devices on the control panel face:

Compressor run lights.

System start-stop switch.

Hand, Off, Auto switch.

[Suction and Discharge Pressure Gages.]

[Compressor lead-lag switch.]

Demand limit switch.

2.4.2.3 Operating Controls

Provide the following operating controls:

[Multi] [____]-step capacity control in response to [leaving] [return] chilled water temperature.

Five minute off timer to prevent short cycling.

[Part-winding start timer.]

Periodic pump-out timer, to pump down on chilled water flow and high evaporator refrigerant pressure.

Load limit thermostat to limit compressor loading on high return chilled water temperature.

Three phase monitor to protect unit by stopping compressor on phase loss, phase reversal, phase unbalance, or under voltage.

Cycle counter and operating hour meter.

Computer switching circuit.

2.4.3 Alarm Package

Furnish an alarm package for [alarm systems](#) with test button. Furnish

lights to indicate when control circuit is energized and compressors are running. Provide an audible alarm and indicating lights to indicate compressor malfunction, low chilled water temperature, and evaporator water flow failure.

2.4.4 Hot Gas Bypass

Provide hot gas bypass valve, and associated control panel wiring and piping, to allow operation of unit below the minimum step of unloading.

2.4.5 Gage Board

Provide factory piped gage-board for each compressor, with pressure gages for suction and discharge refrigerant pressures, and oil pressures.

2.4.6 Vibration Isolators

Provide vibration isolators as recommended by the manufacturer to support complete chiller unit. Refer to Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.

PART 3 EXECUTION

3.1 INSTALLATION

Install chiller assembly in accordance with manufacturer's instructions. [Provide connection for electrical service.]

Provide connections for chilled water piping, condenser water piping, and auxiliary water piping. [Arrange piping for easy dismantling to permit tube cleaning.] Provide piping from safety relief valve to outdoors.

Chilled water inlet piping shall have [thermometer,] [strainer,] [flow switch,] [flexible pipe connector,] [pressure gage,] [and] shut-off valve.

Chilled water outlet piping shall have [flexible pipe connector,] [thermometer,] [pressure gage,] [and] [shut-off] [balancing] valve.

Condenser inlet piping shall have [thermometer,] [strainer,] [flow switch,] [flexible pipe connector,] [pressure gage,] [and] shut-off valve.

Condenser outlet piping shall have [flexible pipe connector,] [thermometer,] [pressure gage,] [and] [shut-off] [balancing] valve.

3.2 MANUFACTURER'S FIELD SERVICE

Contractor shall submit [6] [_____] copies of the [Operation and Maintenance Manuals](#) 30 calendar days prior to testing the water-cooled reciprocating water chiller units. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

Furnish service by factory-trained representative for a period of [_____] calendar days, to conduct training and supervise [dehydration and charging,] testing, and start-up.

3.3 DEMONSTRATION

Demonstrate system operations and verify specified performance.

-- End of Section --