

3.3 DEMONSTRATION

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 42 22 16.00 40

RECIPROCATING PROCESS CHILLERS AND COOLERS 05/11

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

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. 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, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

1.1 SUMMARY

Indicate on shop drawings the general physical layout of reciprocating process [chiller][and][cooler] components, controls, and internal tubing and wiring details. Submit shop drawings and connection diagrams indicating the relations and connections of the following items:

- a. Compressor
- b. Motor
- c. Control diagrams
- d. Control panel
- e. Condenser

- f. Evaporator
- g. Refrigerant circuit
- h. Alarm system
- i. Vibration isolators
- j. Gages

1.2 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) Performance Rating of Water-Chilling Packages Using the Vapor Compression Cycle

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

ASHRAE EQUIP IP HDBK (2012) Handbook, HVAC Systems and Equipment (IP Edition)

ASHRAE EQUIP SI HDBK (2012) Handbook, HVAC Systems and Equipment (SI Edition)

ASHRAE HVAC APP SI HDBK (2011) HVAC Applications Handbook, SI Edition

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (2003; Cor 2005) Mechanical Vibration -

Balance Quality Requirements for Rotors in
a Constant (Rigid) State - Part 1:
Specification and Verification of Balance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2011; Errata 2012) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2014; AMD 1 2013; Errata 2013; AMD 2
2013) National Electrical Code

U.S. DEPARTMENT OF ENERGY (DOE)

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

1.3 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.

The Guide Specification technical editors have
designated those items that require Government
approval, due to their complexity or criticality,
with a "G." Generally, other submittal items can be
reviewed by the Contractor's Quality Control
System. Only add a "G" to an item, 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

Compressor

Motor

Control Diagrams

Control Panel

Condenser

Evaporator

Refrigerant Circuit

Alarm System

Vibration Isolators

Gages

SD-03 Product Data

Chiller Unit

Compressor

Condenser

Accessories

Spare Parts

Vibration Isolators

SD-06 Test Reports

Factory Run Tests

SD-07 Certificates

Certificates of Conformance

Energy Efficiency Rating

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 SYSTEM DESCRIPTION

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:

- a. Chiller unit
- b. Compressor
- c. Condenser
- d. Accessories
- e. Spare parts
- f. Vibration isolators
- g. Motor
- h. Evaporator
- i. Refrigerant circuit
- j. Control panel
- k. Alarm system
- l. Gages

Submit **certificates of conformance** for following items showing conformance with the referenced standards contained in this section:

- a. Compressor
- b. Motor
- c. Control panel
- d. Condenser
- e. Evaporator
- f. Refrigerant circuit
- g. Alarm system
- h. Vibration isolators
- i. Gages

Submit **manufacturer's instructions** for water-cooled reciprocating chiller unit[s] including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

1.4.1 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 48.00 40
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 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND
EQUIPMENT applies to work specified in this section.

] 1.4.2 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: Specify compressor and motor balance
conforming to ISO Std. 1940/1 - (1986) Balance
Quality Requirements of Rigid Rotors - Determination
of Permissible Residual Unbalance unless otherwise
noted. Specify motor vibration levels conforming 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.

Submit factory run tests prior to shipment, indicating capacity, current
draw, and control operation monitoring. 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.

Submit certificates for energy efficiency rating (EER) meeting or exceeding
the full-load efficiency and the integrated part-load value (IPLV)

efficiency ratings as described in AHRI 550/590 and DOE CE-6.

2.2 LIQUID CHILLER

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

Provide reciprocating water chiller unit with a 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, with water head loss not exceeding [_____] 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. Provide close grain cast iron housing, cylinder heads, liners, and handhole covers, with high strength, non-flexing, ring-type suction and discharge valves. Ensure valve plates are cast iron, with ground and lapped seats, with any rotating parts 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

Provide compressor conforming to NEMA MG 1, 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. Provide motor with copper windings and suction gas cooling. Provide solid state sensor and electronic winding overheating protection.

2.3.1.4 Crankcase Heater

Provide immersible type crankcase heater. 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

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

Provide with cleanable [and] [replaceable] [seamless copper] [_____] tubes, 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

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

Provide evaporator with cleanable [and] [replaceable] [seamless copper] [_____] tubes, 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

Ensure each independent refrigerant circuit is factory supplied and piped, 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. Show size, type, and capacity of the systems on electrical diagrams.

Provide with power and control devices, including but not limited to motor starters, relays, timers, fuses, circuit breakers, 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.

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

Provide electronic controls, with adjustable settings, and push-to-test type indicating lights which are 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

Provide a control panel, having separate sections for starter and refrigeration controls, for each compressor and located [on] [near] chiller unit. Ensure starter has 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. Ensure wire identification utilizes preprinted heat-shrink wire sleeves. Hand lettering or marking is not acceptable.

For each control panel, provide the starter section with:

- a. Circuit breaker type combination starter.
- b. Power controls for [across-the-line] [part winding] [_____] starting.
- c. Control power [fuse] [circuit breaker].
- d. Control power transformer for [115] [_____] -volt control voltage.
- e. Terminal blocks, having terminals for the main power supply and all auxiliary connections clearly identified.

- f. Pumpdown control relay.
- g. Compressor starter relay.
- h. Reset relay.
- i. Non-recycling compressor overload relay.
- j. Anti-recycle timer.

For each control panel, ensure the refrigeration section has:

- a. High pressure control.
- b. Low pressure control.
- c. Motor protection.
- d. Oil pressure control.

Mount the following devices on the control panel face:

- a. Compressor run lights.
- b. System start-stop switch.
- c. Hand, off, auto switch.
- [d. Suction and discharge pressure gages.
-] [e. Compressor lead-lag switch.
-] f. Demand limit switch.

2.4.2.3 Operating Controls

Provide the following operating controls:

- a. [Multi] [____]-step capacity control in response to [leaving] [return] chilled water temperature.
- b. Five minute off timer to prevent short cycling.
- [c. Part-winding start timer.
-] d. Periodic pump-out timer, to pump down on chilled water flow and high evaporator refrigerant pressure.
- e. Load limit thermostat to limit compressor loading on high return chilled water temperature.
- f. Three phase monitor to protect unit by stopping compressor on phase loss, phase reversal, phase unbalance, or under voltage.
- g. Cycle counter and operating hour meter.
- h. Computer switching circuit.

2.4.3 Alarm Package

Furnish an alarm package for alarm system 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 48.00 40 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.

Provide chilled water inlet piping with [thermometer,] [strainer,] [flow switch,] [flexible pipe connector,] [pressure gage,] [and] shut-off valve.

Also provide chilled water outlet piping with [flexible pipe connector,] [thermometer,] [pressure gage,] [and] [shut-off] [balancing] valve.

Provide condenser inlet piping with [thermometer,] [strainer,] [flow switch,] [flexible pipe connector,] [pressure gage,] [and] shut-off valve.

Provide condenser outlet piping with [flexible pipe connector,] [thermometer,] [pressure gage,] [and] [shut-off] [balancing] valve.

3.2 MANUFACTURER'S FIELD SERVICE

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 --