Preparing Activity: NASA

Superseding
UFGS-42 22 13.00 40 (August 2014)
UFGS-42 22 13 (May 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

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DIVISION 42 - PROCESS HEATING, COOLING, AND DRYING EQUIPMENT

SECTION 42 22 13.00 40

CENTRIFUGAL PROCESS CHILLERS AND COOLERS

08/17

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SECTION 42 22 13.00 40

CENTRIFUGAL PROCESS CHILLERS AND COOLERS
08/17

NOTE: This guide specification covers the requirements for packaged self-contained hermetic compressor units. Rewrite if unit is not self-contained per definition.

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 item(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

NOTE: Include in drawings or schedule capacity, capacity conditions, pressure drops, control diagrams, and refrigerant used.

NOTE: If Section 23 30 00 HVAC AIR DISTRIBUTION 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. If Section 26 60 13.00 40 LOW-VOLTAGE MOTORS is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.
****

[Section 23 30 00 HVAC AIR DISTRIBUTION 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.

][Section 26 60 13.00 40 LOW-VOLTAGE MOTORS applies to this section.

]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 Reference Identifier (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 480	(2007) Refrigerant-Cooled Liquid Coolers, Remote Type
AHRI 550/590 I-P	(2020) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle
ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units

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

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 21940-11	(2016) Mechanical vibration -- Rotor balancing -- Part 11: Procedures and Tolerances for Rotors with Rigid Behavior

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2021) Motors and Generators

1.2 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S"

classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification 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

Connection Diagrams; G[, [____]]

Control Diagrams; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Centrifugal Water Chiller; G[, [____]]

Compressor; G[, [____]]

Condenser; G[, [____]]

Control and Control Panels; G[, [____]]

Cooler; G[, [____]]

Equipment Foundation Data; G[, [____]]

Insulation; G[, [____]]

Motors; G[, [____]]

Purge System; G[, [____]]

Spare Parts; G[, [____]]

Special Tools; G[, [____]]

Vibration Isolation; G[, [____]]

SD-04 Samples

Manufacturer's Standard Color Chart; G[, [____]]

SD-05 Design Data

Design Analysis and Calculations; G[, [____]]

SD-06 Test Reports

Test Reports; G[, [____]]

SD-07 Certificates

Listing of Product Installation

Referenced Standards Certificates

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings; G[, [____]]

1.3 QUALITY CONTROL

Submit listing of product installation for centrifugal chiller units showing at least five installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Include purchaser name, address of installation, service organization, and date of installation.

1.3.1 Equipment and Performance Data

Submit equipment and performance data for centrifugal water chiller system for the following:

a. Centrifugal Water Chiller

b. Compressor

c. Condenser

d. Cooler

e. Purge System

f. Motors

g. Control and Control Panels

h. Insulation

i. Vibration Isolation

j. Special Tools

k. Spare Parts

1.3.2 Referenced Standards Certificates

Submit certificates for following items, showing conformance with referenced standards in this section:

a. Centrifugal Water Chiller

b. Compressor

c. Condenser

d. Cooler

e. Purge System

f. Motors

g. Control and Control Panels

h. Insulation

i. Vibration Isolation

j. Special Tools

k. Spare Parts

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Drawings and Diagrams

Submit shop drawings of connection diagrams indicating the physical layout of all controls, internal tubing and wiring details, and the relationships and connections of the following items:

a. Centrifugal Water Chiller

b. Compressor

c. Condenser

d. Cooler

e. Purge System

f. Motors

g. Control and Control Panels

Submit control diagrams for centrifugal chiller units showing the physical and functional relationship of equipment. Show on electrical diagrams the size, type, and capacity of the system.

2.1.2 Design Requirements

2.1.2.1 Calculations

Submit design analysis and calculations for centrifugal chillers, indicating the manufacturer's recommended power ratings, rotational speeds, and piston speeds.

Submit equipment foundation data, including equipment weight and operating loads, location and projection of anchor bolts, and horizontal and vertical clearances for installation, operation, and maintenance. Also include dimensions of foundations and relative elevations, and installation requirements such as noise abatement, vibration isolation, physical features, dimensions, ratings, equipment weights, and utility services. Include foundation data for the following:

a. Centrifugal Water Chiller

b. Compressor

c. Condenser

d. Cooler

e. Purge System

f. Motors

[2.1.2.2 Vibration Isolation

Provide vibration isolation conforming to requirements specified in Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

]2.2 COMPONENTS

****
NOTE: Ensure Pump and Motor balance conforms to ISO 21940-11 unless otherwise noted. Ensure Motor vibration levels conform to NEMA Specification MG-1, unless otherwise noted.
****

****
NOTE: Specify all rotating machinery is capable of having shaft alignment and machine balance following installation. This requirement includes "skid-mounted" and "self-contained" units.
****

****
NOTE: Balance is the process of improving the mass distribution of the pump components in order to minimize damaging centrifugal forces. No component can be perfectly balanced. There will always be some remaining unbalance. The minimum recommended balance grade is ISO grade 2.5. Select an ISO grade or insert a standard.
****

2.2.1 Centrifugal Water Chiller Package

Submit centrifugal chiller system information, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Submit equipment and performance data for centrifugal water chillers, indicating the guaranteed maximum brake power at 75, 50, 25, and 10 percent of full compressor capacity at design condenser water temperature. Develop this information from data specified herein.

Submit the manufacturer's standard color chart indicating the standard color selections and finishes for chiller units.

Ensure that the centrifugal water chiller assembly is packaged and self-contained, and that it includes a compressor-condenser, cooler (refrigerant evaporator) accessories, a control panel, and intercomponent piping and wiring ready for field-terminal connections.

Provide a unit and spare parts conforming to the applicable requirements

of AHRI 550/590 I-P, AHRI 480, and specified requirements. Ensure that the unit's Energy Efficiency Rating (EER) meets or exceeds the full-load efficiency and the integrated part-load value (IPLV) efficiency ratings as described in AHRI 550/590 I-P.

2.2.2 Compressor

****

NOTE: At higher than 3,600 rpm speeds, reevaluate 0.025 millimeter 0.001 inch vibration limit. Do not use compressor that will operate at 20,000 or higher rpm.

****

Provide a [single] [multistage], [direct] [gear-driven] centrifugal compressor, with hermetically sealed compressor-motor assembly. Provide the unit with [refrigerant] [water-cooled] motor windings. Ensure that the rotor assembly is statically and dynamically balanced to ISO 21940-11, [G6.3] [G2.5] [G1.0] [_____], with replaceable sleeve-insert shaft main bearings.

Provide a forced-feed compressor lubrication system with oil sump, hermetically sealed motor-driven positive displacement pump, and oil filter, strainer, with oil temperature thermostatically controlled. Provide a mechanically operated oil supply to the bearings during spin-down. Include an interlocked differential oil-pressure cutout with starting equipment, which allows the compressor to operate only when the required oil pressure is available at the bearings.

Provide a compressor with temperature-actuated capacity reduction. Select a multiple radial blade or butterfly-damper variable-frequency-drive (VFD) compressor motor control to provide automatic capacity regulation from 100 percent to 10 percent of capacity. Where it is necessary in order to maintain stable operation, provide an automatic hot-gas bypass with the control system, including automatic stopping when load falls below 10 percent capacity, and automatic unloaded restarting on load demand. Ensure that the capacity modulation is controlled by the temperature of the water leaving the cooler, and that the unit controller maintains the water at its leaving temperature plus or minus 0.25 degrees C 0.5 degree F of the set point.

2.2.3 Condenser

Provide a cleanable shell-and-tube condenser complying with ASHRAE EQUIP SI HDBK, Chapter 13, and ASME BPVC SEC VIII D1 for the quality of materials used, the methods of construction, the design of components, and the testing of materials, assemblies, connections, and appurtenances. Ensure that the minimum water-side working pressure is 1050 kilopascal 150 psig. Minimum refrigerant-side working pressure is the saturation pressure of refrigerant used at 29 degrees C 85 degrees F. Pneumatically test spaces not subject to ASME code due to size or other limitations at 1-1/2 times working pressure or 310 kilopascal 45 psig, whichever is greater.

Provide seamless copper tubing with integral fins, individually removable from either end of shell, rolled or brazed into tube sheet. Provide intermediate tube supports so that distance between supports does not exceed approximately 900 millimeter 3 feet. Fit supports to the tubes in a manner that precludes corrosion, vibration, and abrasion.

Fit and arrange water boxes or removable elbows to permit cleaning of tubes without disturbing piping beyond elbows, with flanged- or grooved-coupling elbows, and hinged-mounted end bells.

Design the unit to permit pump-down and isolation of the entire refrigerant charge within 80 percent of available condenser volume. If the unit condenser does not have sufficient pump-down capacity, provide a separate pump-out tank.

****

NOTE: Many present-day nonchromate water treatment chemicals degrade at temperatures as low as 38 to 57 degrees C 100 to 135 degrees F and tend to severely foul heat-transfer surfaces. The difference between a fouling factor of 0.0005 and 0.001 could approximate 7 percent of machine capacity. Cost of unit with 0.001 fouling factor will be higher and may be restrictive.

Limiting water velocity to 2 meter per second 7 feet per second (fps) could force selection of next larger size machine.

Tube protectors are usually required at velocities in excess of 2 meter per second 7 fps.

Select one of the following two paragraphs. Normally, select the first paragraph.

****

Base the condenser performance on a maximum water velocity of 3 meter per second 10 feet per second (fps) and a fouling factor of 0.001. Ensure that design and construction provisions preclude tube failure due to erosion.

Base the condenser performance on a maximum water velocity of 2 meter per second 7 fps and a fouling factor of 0.001.

2.2.4 Cooler (Refrigerant Evaporator)

Provide a cooler conforming to the requirements specified in the paragraph CONDENSER and the following:

Base the cooler capacity on a refrigerant suction temperature in excess of 0 degrees C 32 degrees F and a fouling factor of 0.0005.

Provide a frangible safety relief device. Pipe the device to the building exterior.

2.2.5 Purge System

When a positive-pressure refrigerant is used by the manufacturer in the basic liquid chiller unit, a purge system is not required.

When the purge system is in operation, ensure that it automatically removes air, water vapor, and noncondensable gases from the refrigeration system, and that it condenses, separates, and returns any refrigerant present therein to the system. Ensure that the purge system manually or

automatically starts and stops and is assembled as a compact unit. Verify that the purge system is complete with operating and safety devices, with an oil separator if recommended by the manufacturer. Ensure that units purge no more than 0.045 kg 0.1 pounds of noncondensable gas.

2.2.6 Control and Control Panels

****

NOTE: Select the following paragraph only after checking control panel sizes and numbers to be sure they can be unit mounted. Some or all starters may be mounted in motor control center and unit will not be totally self-contained.

Coordinate with Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC and electrical requirements.

****

Provide a water-chilling unit with one or more control panels containing safety and operating devices and intercomponent piping and wiring for field-terminal connection and fully automatic operation.

Coordinate the controls with the automatic temperature controls systems and electrical work specified and indicated. Provide a control panel containing the control equipment specified. Provide the control equipment normally furnished and recommended by the manufacturer for optimum operation of the system. Permanently identify all control panel items, including the following:

****

NOTE: The following are manufacturer's standard items. If the last two listed items, motor controllers and NEMA 1 enclosures, are specified elsewhere, delete from this paragraph.

****

a. Refrigerant suction and discharge pressure gages

b. Oil-pressure gages

c. Purge-drum pressure gage

d. Refrigerant low-temperature or low-pressure cutout

e. Refrigerant high-pressure cutout

f. Time delay relays

g. Motor high-temperature cutout

h. Lubricating-oil high-temperature cutout if required by equipment

i. Oil differential-pressure interlock

j. Interlock relays and reset button

k. Manual/automatic selector switches and controls for purge pumps

l. Pilot lights indicating position of safety controls

m. System start/stop provisions with condition-indicating lights

n. Load-limiting device to operate capacity-control mechanism

o. Cooler refrigerant thermometer with well

p. Main circuit protective and interruptive device

q. Transformers for any other source-voltage requirements

r. Terminals for field-installed equipment

[s. Motor controllers

][t. NEMA 250, Type 1 enclosures

] Provide the following items as part of the installation:

****
NOTE: Coordinate with drawings. Select, delete, or supplement. These are normally field-installed by the Contractor.
****

a. Audible-alarm bell, 100 millimeter 4-inch diameter

b. Chilled-water and condenser supply-and-return thermometers with wells

c. Indicating-type chilled-water thermostat with well

d. Chilled-water low-temperature cutout

2.2.7 Motors

Provide hermetically sealed motors conforming to NEMA MG 1, ANSI/AHRI 520 and requirements for motors as specified herein.

Provide with [oil-lubricated, replaceable-sleeve, insertable] [permanently lubricated, rolling-element] bearings.

****
NOTE: Limit percent of full-load amperes at which motor controller overload will trip, gas pressure differential, pumps, sprays, unit capacity, or other. Coordinate with motor controller specification and drawings.
****

[Provide the motor with two manually resettable thermal-overload protective devices located within windings.
]

****
NOTE: Coordinate the following with the following motor controller specification and drawings. Rewrite as necessary to suit designed size and type equipment.
****

If the water-chilled unit or any component could be damaged by reverse motor operation, and when the proposed water-chiller unit contains a mechanically driven lubricating-oil pump, the manufacturer's responsibility includes:

a. Providing reverse-phase rotation protection, if motor controllers are provided as part of package.

b. Indicating in shop drawings that reverse-phase rotation protection is necessary if motor controllers are in a motor control center not provided by the manufacturer.

[2.2.8 Insulation

****
NOTE: Select the following paragraphs only when specified equipment is to be provided with factory insulation. Normally provide for field insulation of cooler headers.
****

Insulate and vapor-seal the cooler shell and suction piping between the evaporator and the first stage of each compressor unit. Insulate the water boxes, allowing for ease of access to heads for inspection and repair. Where motors are gas-cooled, provide insulation and a vapor seal on the cold-gas inlet connection to the motor.

Provide the manufacturer's standard color elastomeric unicellular foam vapor seal material of 25 millimeter 1 inch minimum thickness to preclude condensation of ambient moisture on any surface under site-operating conditions. If unicellular material is black or is otherwise coated, use only polyvinylchloride lacquer for coating. When any coating cracks when unicellular material is compressed, remove the coating and replace it with the specified coating at no additional expense to the Government.

]PART 3 EXECUTION

3.1 INSTALLATION

Install equipment as specified, and in accordance with manufacturer's installation drawings and written instructions, including the ratings and service requirements.

3.1.1 Alignment

Before attempting alignment, demonstrate that the pump does not have any load/force imposed by the piping system. Minimum alignment values (below) are for pump and driver at normal running temperatures. Ensure that the values are compensated for thermal growth. Ensure that the limited movement of the pump or driver (commonly known as bolt-bound) is corrected to ensure alignment capability. Do not undercut hold-down bolts in order to perform adjustment.

Provide commercially die-cut shims, without seams or folds, made of corrosion-resistant stainless steel. Use no more than four shims at any single point.

Provide installed alignment jack bolts on all units with a drive motor

over [7.5][10][15][20][25] hp.

Provide a pump and driver with an intermediate shaft, spacer, or spool piece (sometimes called a jackshaft). Based on the motor nominal operating speed, align the pump and driver to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle (mils/in)	Spool Piece Angle @coupling pt.
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5

Perform pump alignment under the direction of the manufacturer's representative.

Provide final alignment settings as part of the final test data.

3.2 FIELD QUALITY CONTROL

3.2.1 Inspection and Testing

Completely charge the unit(s) with refrigerant and oil before operation.

Prior to final acceptance, verify pump and motor conformance to specifications, using vibration analysis, with vibration levels not exceeding 1.77 mm per second0.075 inch per second at 1 times run speed and at pump frequency, and 3.5 mm per second0.04 inch per second at other multiples of run speed.

Use a Fast Fourier Transformer (FFT) analyzer to measure vibration levels, having the following characteristics:

a. Dynamic range greater than 70 dB;

b. A minimum line resolution of 400;

c. A frequency response range of 5 Hz to 10 KHz(300 to 600,000 cpm);

d. The capacity to perform ensemble averaging;,

e. The capability to use a Hanning window;

f. Autoranging frequency amplitude;

g. A minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

h. An accelerometer, either stud-mounted or mounted using a rare-earth, low-mass magnet and sound disk(or finished surface) used with the FFT analyzer to collect data.

Ensure that the mass of the accelerometer and its mounting have minimal influence on the frequency response of the system over the selected measurement range.

Upon completion of the installation, and within 60 calendar days after the date of initial operation, conduct performance tests in the presence of the Contracting Officer. Conduct these tests until the performance of the system is proven, with [8][_____] hours of successful operation as a minimum period. Correct any equipment defects or performance deficiencies, and repeat the tests until performance is fully accepted by the Contracting Officer. Determine the water flows by using the pressure-drop across the chiller and condenser and reading the pump curves. Provide calibrated test instruments. Government will provide the load.

Ensure that each unit is tested for leaks under pressure and evacuated and dehydrated to 2 degrees C 35 degrees F wet bulb, or an absolute pressure of not over 813 pascal 0.24 inch of mercury

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.2.2 Manufacturer's Representative

Provide the services of a competent factory-trained representative to supervise the assembly, charging, testing, and startup of equipment. Provide documentation that a factory performance test has been conducted on every chiller in accordance with AHRI 550/590 I-P[, witnessed by the Government and Contractor].

3.3 CLOSEOUT ACTIVITIES

Provide [one] [_____] complete set[s] of special tools, as recommended by the manufacturer, for field maintenance of the system, in a locked toolbox. Provide two [sets of]keys to the Contracting Officer.

Make provisions for Government personnel to receive [8][_____] hours of instructions in proper operation and maintenance procedures.

Submit [six] [_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the centrifugal chiller system. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

Submit record drawings for centrifugal chiller units, providing current factual information, including deviations from and amendments to the drawings and changes in the work.

-- End of Section --