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USACE / NAVFAC / AFCEC **UFGS-23 64 10 (May 2025)**

Preparing Activity: NAVFAC **Superseding**
UFGS-23 64 10 (November 2016)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2025
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SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE

05/25

-- End of Section Table of Contents --

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SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE
05/25

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NOTE: This guide specification covers the requirements for water chilling equipment.

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)**.**
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PART 1 GENERAL

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NOTE: Chiller performance and capacity data must be shown in the equipment schedule on the drawings and must contain the following minimum information: Equipment tag, type of compressor, refrigerant type, variable speed drive requirements (if applicable), vibration isolation type, site elevation, electrical requirements including minimum Short Circuit Current Rating (SCCR) and MOCP, efficiency and relevant ANSI/ASHRAE Standard, capacity and performance data and associated flow and pressure drop data, maximum allowable sound pressure levels.

Drawing information must include, as a minimum,

accurate chiller footprint, required service clearances including overhead and tube pull clearances, air circulation clearances, electrical connection/panel NEC service clearances, piping connections and accessories details, refrigerant relief piping layout for indoor chillers showing compliance with the ANSI/ASHRAE 15 and the Mechanical Code, refrigerant leak detection system(s) for indoor chillers and associated required exhaust and ventilation systems, emergency "CHILLER SYSTEM EMERGENCY STOP" stations and "EMERGENCY EXHAUST SYSTEM START" stations as required by the Mechanical Code

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1.1 REFERENCES

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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.

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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 450	(2007; R 2024) Water-Cooled Refrigerant Condensers, Remote Type
AHRI 460	(2024) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant COndensers
AHRI 480	(2007) Refrigerant-Cooled Liquid Coolers, Remote Type
AHRI 550/590 I-P	(2023) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle
AHRI 575	(2017; R 2020) Method of Measuring

	Machinery Sound Within an Equipment Space
AHRI 580	(2014; R2022) Performance Rating of Non-condensable Gas Purge Equipment for Use with Low Pressure Centrifugal Liquid Chillers

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014; R 2020) Load Ratings and Fatigue Life for Roller Bearings

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

ANSI/ASHRAE 15 & 34	(2022) ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 90.1 - IP	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC VIII D1	(2023) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) Safety in Welding, Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A307	(2023) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2025) Standard Specification for Zinc Dust Pigment
ASTM E84	(2024) Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM F104 (2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 00001 (2024) Motors and Generators

NEMA MG 10009 (2022) Energy Management Guide for Selection and Use of Single-Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 37 (2024; TIA 24-1) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 54 (2024) National Fuel Gas Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537 (2023) Storage Batteries

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82 Protection of Stratospheric Ozone

UL SOLUTIONS (UL)

UL 1236 (2015; Reprint Feb 2021) UL Standard for Battery Chargers and Charging Engine-Starter Batteries

1.2 SUBMITTALS

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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 and Air Force 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.
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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. Submittals not having a "G" or "S" classification are 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-03 Product Data

Posted Instructions

Verification of Dimensions

System Performance Tests

Demonstrations

Refrigerant

[Water Chiller - Field Acceptance Test Plan

] [Scroll][Reciprocating][Rotary Screw] Type Water Chiller[s]

Centrifugal Type Water Chiller[s]

Air-Source Heat Pump Type Water Chiller[s] (Non-Reversible)

Water-Source Heater-Chiller Type Water Chiller[s] (Non-Reversible)

Air-Source Heat Pump Type Water Chiller[s] (Reversible)

Water-Source Heater-Chiller Type Water Chiller[s] (Reversible)

Water-Source Multipipe Type Water Chiller[s] (Simultaneous Heating and Cooling)

Split-System Water Chiller[S]

SD-06 Test Reports

Field Acceptance Testing

[Water Chiller - Field Acceptance Test Report

] Factory Tests

System Performance Tests

Factory Test Schedule; G, [_____]

SD-07 Certificates

Refrigeration System; G, [_____]

Refrigeration Technician Certification

SD-08 Manufacturer's Instructions

[Water Chiller - Installation Instructions; G, [_____]

] SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, [_____]

Training Course Schedule; G, [_____]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 CERTIFICATIONS

1.3.1 Refrigeration Technician Certification

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NOTE: The following paragraph requires a certification for technicians who work on equipment that could release Class I or II refrigerants, such as R-123, into the atmosphere. This is required as of January 1, 2018 to meet the requirements of 40 CFR 82, Subpart F.

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All technicians working on equipment that contain Class I or II refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation is the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.6 PROJECT REQUIREMENTS

1.6.1 Verification of Dimensions

The Contractor must become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

PART 2 PRODUCTS

****

NOTE: Job specifications will be written to avoid restrictions on specific types of refrigerant (excluding CFC refrigerants) in order to encourage competitive bidding of available product offerings.

Electric chillers are required to meet performance requirements specified by FEMP. The link for energy requirements for air-cooled chillers is found at: https://www.energy.gov/femp/purchasing-energy-efficient-air-cooled-electric-chillers

Information on requirements for water-cooled chillers and energy requirements for water-cooled chillers can be found at: https://www.energy.gov/femp/purchasing-energy-efficient-water-cooled-electric-chillers

These specifications conform to the efficiency requirements as defined in Public Law (PL) 109-58 - "Energy Policy Act of 2005" for federal procurement of energy-efficient products. Equipment selected will have as a minimum the efficiency ratings.

Performance requirements for air-cooled chillers are provided in both kilowatt (kW)/ton and energy efficiency ratio (EER or Btu/watt) units for convenience. When comparing only air-cooled chillers, EER (Btu/watt) is a common metric. When comparing air-cooled and water-cooled chillers, kW/ton is a common metric. Performance requirements for water-cooled chillers are provided in kW/ton.

Project specific performance characteristics must be based on the project site elevation above sea level, and clearly noted as such on the submittal.

Equipment having a lower efficiency than FEMP requirements may be specified if the designer determines the equipment to be more life-cycle cost effective using the life-cycle cost analysis methodology and procedure in 10 CFR 436.

The driving forces in the procurement of higher efficient equipment are Executive Orders 13423 and 13514.

When editing this specification to eliminate a type of chillers technology (oil-free magnetic bearings

compressors versus oil-lubricated compressors), the design analysis must include both calculations to demonstrate that the edit is the most LCC effective and manufacturer's literature demonstrating that this edit does not result in a sole-source chiller procurement. However, for Army and Air Force projects, the installation may have a policy requiring a sole-source for chillers. Coordinate with the Installation to determine the required chiller provider, and seek sole-source approvals as necessary.

Minimum chiller efficiencies must be specified in the chiller schedule on the drawings and include the applicable AHRI rating standard. Any specified chiller efficiencies in the specification needs to be avoided.

Use minimum full load and part load efficiency ratings to specify electrically driven, air-cooled and water-cooled water chillers.

Projects which include vapor-compression type water chillers will comply with the safety standards defined in ASHRAE 15. Designers will be responsible for thoroughly researching and implementing the ASHRAE 15 safety requirements.
****

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment must be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. These products must have a two year record of satisfactory field service prior to bid opening. The two year record of service must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year record of satisfactory field service is acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record must not include any manufacturer's prototype or factory testing. Satisfactory field service must have been completed by a product that has been, and presently is being sold or offered for sale on the commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

****
NOTE: In a salt water environment, substitute acceptable non-corroding metal such as but not limited to nickel-copper, 304 stainless steel, or monel. Aluminum is unacceptable. Nomenclature (or system identification) should be established by the designer.

Choose first bracketed paragraph for Army projects. Second bracketed paragraph for Navy projects.
****

[Major equipment including chillers, compressors, compressor drivers, condensers, water coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life. Fix plates in prominent locations with nonferrous screws or bolts.

][Nameplates are required on major components if the manufacturer needs to provide specific engineering and manufacturing information pertaining to the particular component. Should replacement of this component be required, nameplate information must insure correct operation of the unit after replacement of this component.

]2.3 ELECTRICAL WORK

****

NOTE: Where motor starters for mechanical equipment are provided in motor-control centers, the references to motor starters will be deleted.

Show the electrical characteristics, motor starter type(s), enclosure type, and maximum rpm on the drawings in the equipment schedules.

Where reduced-voltage motor starters are recommended by the manufacturer or required otherwise, specify and coordinate the type(s) required in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Reduced voltage starting is required when full voltage starting will interfere with other electrical equipment and circuits and when recommended by the manufacturer. Where adjustable speed drives (ASD) are specified, reference Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS. The methods for calculating the economy of using an adjustable speed drive is described in UFC 3-520-01, "Interior Electrical Systems".

****

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, electronically commutated motors, including motors that are part of a system, in accordance with NEMA MG 10009.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 00001.

****
NOTE: Bracketed sentence "Motor bearings..." to be used for Army projects only.
****

d. Provide motors in accordance with NEMA MG 00001 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances.[Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.] Motor enclosure type may be either TEAO or TEFC.

e. [Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function.][Use adjustable frequency drives for all variable-speed motor applications.]Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 SELF-CONTAINED WATER CHILLER[S], VAPOR COMPRESSION TYPE

****
NOTE: Typically, units 1760 kW 500 tons or smaller are fully assembled and run-tested at the factory. Units larger than 1760 kW 500 tons are typically shipped and then assembled, charged, and run-tested in the field.
****

Unless necessary for delivery purposes, units must be assembled, leak-tested, charged (refrigerant[and oil]), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant[and oil]), and adjusted at the job site by a factory representative. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Unit assembly must be completed in strict accordance with manufacturer's recommendations. Parts weighing 23 kg 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, must have lifting eyes or lugs. Chiller must include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Provide chiller with a single point wiring connection for incoming power supply, unless noted otherwise on the drawings. Chiller must operate within capacity range and speed recommended by the manufacturer. Chiller must operate at partial load conditions without increased vibration over normal vibration at full load, and must be capable of continuous operation down to the specified minimum capacity.

2.4.1 [Scroll][Reciprocating][Rotary Screw] Type Water Chiller[s]

****
NOTE: These type units are typically available in capacities of 1760 kW 500 tons or less.
****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit per compressor

d. Controls package

e. Scroll, reciprocating, or rotary screw compressor

f. Compressor driver,[electric motor][gas-engine]

g. Compressor driver connection

h. Water cooler (evaporator)

i. [Air-cooled condenser coil][Water-cooled condenser]

[j. Heat recovery condenser

][k. Receiver

][l. [Air-Source Economizer][Water-source Economizer]

] **
NOTE: Tools to be used for Army projects only.
****

[m. Tools

]2.4.2 Centrifugal Type Water Chiller[s]

****
NOTE: These type units are typically available in capacities of 528 kW 150 tons or more.
****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant[and oil]

b. Structural base

c. Chiller refrigerant circuit per compressor

d. Controls package

e. Centrifugal compressor

f. Compressor driver,[electric motor][gas-engine]

g. Compressor driver connection

h. Water cooler (evaporator)

i. Water-cooled condenser

[j. Heat recovery condenser coil

][k. Receiver

] l. Purge system for chillers which operate below atmospheric pressure

[m. Water-Source Economizer

] **

NOTE: Tools to be used for Army projects only.

****

[n. Tools

]2.4.3 Air-Source Heat Pump Type Water Chiller[s] (Non-Reversible)

****

NOTE: These type units use their condenser to indirectly generate coincidental hot water for heating, typically available up to 457 kW 130 tons of cooling. BTUH heating output and supply temperature of hot water generated depend on many factors and must be discussed with the chiller manufacturer early in the project.

****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must perform heat pump functions such that, while producing chilled water, its air-cooled condenser system is used to generate heating hot water of capacity and temperature as noted on the drawings. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll compressor(s)

b. Refrigerant and oil

c. Structural base

d. Chiller refrigerant circuit per compressor

e. Controls Package

Controls package must include self-contained DDC-based software to control the chiller's heat pump functions to generate chilled water and incidental hot water via its condenser system.

f. Compressor driver

g. Compressor driver connection

h. Water cooler (evaporator)

i. Air-cooled condenser coil

j. Heat recovery condenser

k. Receiver

****
NOTE: Tools to be used for Army projects only.
****

[l. Tools

]2.4.4 Water-Source Heater-Chiller Type Water Chiller[s] (Non-Reversible)

****
NOTE: Typically available up to 7034 kW 2000 tons of cooling, when in cooling mode these type units control to a chilled water temperature setpoint, and use their condenser to directly generate coincidental hot water for heating. When in heating mode, these units control to a condenser water temperature setpoint and provide coincidental chilled water on the evaporator side. BTUH heating outputs and supply temperature of hot water generated depend on many factors and must be discussed with the chiller manufacturer early in the project.
****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must conform to ANSI/ASHRAE 15 & 34. Chiller must have two modes of operation, Cooling Mode - chilled water production with simultaneous coincidental hot water production via the condenser, and Heating Mode - hot water production with simultaneous coincidental chilled water production via the evaporator, of capacities and temperatures as noted on the drawings. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, screw or centrifugal compressor(s)

b. Refrigerant[and oil]

c. Structural base

d. Chiller refrigerant circuit per compressor

e. Controls package

In addition, the controls package must include self-contained DDC-based software to control the chiller's production of chilled water and hot water via cooling-heating mode selection.

f. Compressor driver

g. Compressor driver connection

h. Water cooler (evaporator)

i. Water-cooled condenser

j. Receiver

k. Purge system for chillers which operate below atmospheric pressure

****
NOTE: Tools to be used for Army projects only.
****

[l. Tools

]2.4.5 Air-Source Heat Pump Type Water Chiller[s] (Reversible)

****
NOTE: These type units use reversing valves to either produce chilled water for cooling, or hot water for heating, but cannot do both simultaneously, typically available up to 809 kW 230 tons of cooling. BTUH heating output and supply temperature of hot water generated depend on many factors and must be discussed with the chiller manufacturer early in the project.
****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must have refrigeration reversing valve(s) to provide two modes of non-simultaneous operation, Cooling Mode - chilled water production, and Heating Mode - hot water production, of capacities and temperatures as noted on the drawings. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll compressor(s)

b. Refrigerant and oil

c. Structural base

d. Chiller refrigerant circuit per compressor

e. Controls package

In addition, the controls package must include self-contained DDC-based software to control the chiller's production of chilled water or hot water via cooling-heating mode selection.

f. Compressor driver

g. Compressor driver connection

h. Water cooler (evaporator)

i. Air-cooled condenser coil

j. Receiver

****

NOTE: Tools to be used for Army projects only.

****

[k. Tools

]2.4.6 Water-Source Heater-Chiller Type Water Chiller[s] (Reversible)

****

NOTE: These type units use reversing valves to either produce chilled water for cooling, or hot water for heating, but cannot do both simultaneously, typically available up to 2814 kW 800 tons of cooling (80-ton modules). BTUH heating output and supply temperature of hot water generated depend on many factors and must be discussed with the chiller manufacturer early in the project.

****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must have refrigeration reversing valve(s) to provide two modes of non-simultaneous operation, Cooling Mode - chilled water production and Heating Mode - hot water production, of capacities and temperatures as noted on the drawings. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll compressor(s)

b. Refrigerant and oil

c. Structural base

d. Chiller refrigerant circuit per compressor

e. Controls package.

In addition, the controls package must include self-contained DDC-based software to control the chiller's production of chilled water or hot water via cooling-heating mode selection.

f. Compressor driver

g. Compressor driver connection

h. Water cooler (evaporator)

i. Water-cooled condenser

j. Receiver

****

NOTE: Tools to be used for Army projects only.

****

[k. Tools

]2.4.7 Water-Source Multipipe Type Water Chiller[s] (Simultaneous Heating and Cooling)

****

NOTE: Typically available up to 480 tons of cooling (60-ton modules). Each module can be indexed to heating or cooling, thus multiple-module machines can simultaneously deliver chilled water and heating hot water as a package thru a series of pipe and valve configurations. BTUH heating outputs and supply temperature of hot water generated depend on many factors and must be discussed with the chiller manufacturer early in the project.

****

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller must be of modular design such that each module can be indexed to heating mode or cooling mode, providing simultaneously production of chilled water and hot water as a package through a series of pipe and automatic valve configurations. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll compressor(s)

b. Refrigerant and oil

c. Structural base

d. Chiller refrigerant circuit per compressor

e. Controls package.

In addition, the controls package must include self-contained DDC-based software to control the chiller's simultaneous production of chilled water and hot water via associated indexing and automatic control valves.

f. Compressor driver

g. Compressor driver connection

h. Water cooler (evaporator)

i. Water-cooled condenser

j. Receiver

****

NOTE: Tools to be used for Army projects only.

****

[k. Tools

]2.5 SPLIT-SYSTEM WATER CHILLER[S], VAPOR COMPRESSION TYPE

****

NOTE: Typically, units 1760 kW 500 tons or smaller are fully assembled and run-tested at the factory. Units larger than 1760 kW 500 tons are typically shipped and then assembled, charged, and run-tested in the field.

****

Total chiller system must be certified for performance per AHRI 550/590 I-P. If chiller is not in scope of AHRI 550/590 I-P then chiller must be rated in accordance with AHRI 550/590 I-P. Individual chiller components must be constructed and rated in accordance with the applicable AHRI standards. In addition, project specific performance data must be based on the project site elevation above sea level, and clearly noted as such on the submittal. Chiller system must conform to ANSI/ASHRAE 15 & 34. The chiller must be ASHRAE 90.1 - SI ASHRAE 90.1 - IP compliant and meet 10 CFR Part 433, 434 and 435 efficiency performance standards for federal construction. The manufacturer must provide certification of compliance. Chiller must be assembled, leak-tested, charged (refrigerant[and oil]), and adjusted at the job site in strict accordance with manufacturer's recommendations. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Unit assembly must be completed in strict accordance with manufacturer's recommendations. Chiller must operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg 50 pounds or more which must be removed for inspection, cleaning, or repair, must have lifting eyes or lugs. Chiller must include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's water cooler must be provided with[standard][marine] water boxes with[grooved mechanical][flanged][welded] connections. Chillers must operate at partial load conditions without increased vibration over normal vibration at full load, and must be capable of continuous operation down to the specified minimum capacity. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant[and oil]

b. Structural base

c. Chiller refrigerant circuit per compressor

d. Controls package

[e. Receiver

] **

NOTE: Tools to be used for Army projects only.

****

[f. Tools

]2.5.1 Compressor-Chiller Unit

****

NOTE: These type units are typically available in capacities of 1406 kW 400 tons or less.

****

As a minimum, the compressor-chiller unit must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Water cooler (evaporator)

2.5.2 Condensing Unit

****

NOTE: These type units are typically available in capacities of 1406 kW 400 tons or less.

****

As a minimum, the condensing unit must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Air or water cooled condenser

2.5.3 Remote Water Cooler (Evaporator)

****
NOTE: Confirm the current standard fouling factor with AHRI.
****

2.5.3.1 Shell and Tube Type

****
NOTE: Coil bundles to be used for Army projects only.
****

Cooler must be constructed and rated in accordance with AHRI 480. Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side must be designed and factory pressure tested for not less than [1,000][1,700][2,000] kPa [150][250][300] psi. Cooler shell must be constructed of seamless or welded steel.[Coil bundles must be totally removable and arranged to drain completely.] Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Cooler must be skid-mounted. Refrigerant circuit must be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance must be based on a fluid velocity not less than 0.91 m/s 3 fps and not more than 3.7 m/s 12 fps and a fouling factor per AHRI 550/590 I-P.[Evaporator must be provided with electric freeze protection type.]

2.5.3.2 Brazed Plate Type

Cooler must be rated in accordance with AHRI 480. Cooler must be of the brazed plate design. Cooler's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side must be designed and factory pressure tested for not less than [1,000][1,700][2000] kPa [150][250][300] psi. Cooler shell must be constructed of stainless steel plates brazed together with copper. Refrigerant circuit must be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance must be based on a fluid velocity not less than 0.91 m/s 3 fps and not more than 3.7 m/s 12 fps and a fouling factor per AHRI 550/590 I-P.[Evaporator must be provided with electric freeze protection type.]

2.5.4 Remote Air-Cooled Condenser

****
NOTE: Louvered panels beneath the condenser are only available for certain models and certain manufacturers and can affect performance. Verify their need and availability before specifying.
****

Condenser must be a factory-fabricated and assembled unit, consisting of coils, fans, and condenser fan motors. Condenser must be rated in accordance with AHRI 460. Louvered panel coil guards must be provided by the manufacturer to prevent physical damage to the coil.[In addition, provide louvered panels below the coils to provide additional protection of underneath components.] Manufacturer must certify that the condenser and associated equipment are designed for the submitted condensing temperature. For design conditions, if matched combination catalog ratings matching remote condensers to compressors are not available, the Contractor must furnish a cross-plotting of the gross heat rejection of the condenser against the gross heat rejection of the compressor, for the design conditions to show the compatibility of the equipment furnished.

2.5.4.1 Condenser Casing

Condenser casing must be aluminum not less than [1.016][2.032] mm [0.040][0.080] inch or hot-dip galvanized steel not lighter than 18 gauge 1.311 mm 0.0516 inch.[Condensers having horizontal air discharge must be provided with discharge baffle to direct air upward, constructed of the same material and thickness as the casing].

2.5.4.2 Coil

[Condenser coil must be of the extended-surface fin-and-tube type and must be constructed of seamless[copper][or][aluminum] tubes with compatible[copper][or][aluminum] fins. Fins must be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils must be circuited and sized for a minimum of 3 degrees C 5 degrees F subcooling and full pump-down capacity. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.][The condenser coil must be of the microchannel heat exchanger technology (MCHX) type consisting of a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds in a two-pass arrangement. Provide coils constructed of aluminum alloys for fins, tubes, and manifolds. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.]

[Coil must be entirely coated in accordance with the requirements of paragraph COIL CORROSION PROTECTION.

]2.5.4.3 Fans

****
NOTE: Belt drives to be used for Army projects only.
****

Provide centrifugal or propeller type fans as best suited for the application. Fans must be direct[or][V-belt] driven.[Belt drives must be completely enclosed within the unit casing or equipped with a guard.][When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment must be provided. Sheave sets must be matched and selected to provide the capacity indicated at the approximate midpoint of the adjustment.] Fans must be statically and dynamically balanced.

2.5.4.4 Condenser Sizing

Size condensers for full capacity at 16.67 degrees C 30 degrees F temperature difference between entering outside air and condensing refrigerant. Subcooling must not be considered in determining compressor and condenser capacities. For design conditions, submittal must include a cross-plot of net refrigeration effect of compressor to establish net refrigeration effect and compatibility of equipment furnished.

2.5.4.5 Low Ambient Control

Provide factory mounted head pressure control for operation during low ambient conditions. Head pressure must be controlled by[fan cycling,][fan speed control,][condenser refrigerant flooding]. Low ambient control must permit compressor operation below [4.4][minus 17.7][_____] degrees C [40][zero][_____] degrees F.

2.5.4.6 High Ambient Unloading

****

NOTE: High Ambient control may be required for water cooled chillers utilizing river or lake water. Verify historic peak water temperature for the specific site.

****

Provide unloading capability to allow operation in high ambient conditions [[_____] degrees C degrees F] above design conditions.

2.5.5 Remote Water-Cooled Condenser

****

NOTE: Coil bundles to be used in Army projects only.

****

Condenser must be a factory-fabricated and assembled unit constructed and rated in accordance with AHRI 450. Condenser may be of either the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than [1,000][1,700][2000] kPa [150][250][300] psi. Condensers must be complete with pressure relief valve or rupture disk, water drain connections, refrigerant charging valve, refrigerant valves, liquid-level indicating devices, and stand or saddle. Low pressure refrigerant condenser must be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell must be constructed of seamless or welded steel.[Coil bundles must be totally removable and arranged to drain completely.] Tubes may be either seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Condenser performance must be based on water velocities not less than 0.91 m/s 3 fps nor more than 3.7 m/s 12 fps and a fouling factor per AHRI 550/590 I-P. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 20 percent in excess of the fully charged system for remote water cooled condensers. As a minimum, the condenser must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Liquid-level indicating devices.

b. Companion flanges, bolts, and gaskets for flanged water connections.

2.6 CHILLER COMPONENTS

****
NOTE: Coordinate the type of chiller components required with the type of chiller specified in the previous paragraphs.
****

2.6.1 Refrigerant

****
NOTE: Chillers must operate on a refrigerant with an ODP equal to 0 and a maximum Global Warming Potential (GWP) of 700. R-32, R-454B, R-513A, R-514A, R-515B, R-1233zd, R-1234ze all meet this requirement.
****

Refrigerants must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. CFC-based refrigerants are prohibited. Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0 and a maximum Global Warming Potential (GWP) of 700. Provide SDS sheets for all refrigerants.

2.6.2 Structural Base

Chiller and individual chiller components must be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components must be isolated from the building structure by means of[molded neoprene isolation pads.][vibration isolators with published load ratings. Vibration isolators must have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.]

2.6.3 Chiller Refrigerant Circuit

****
NOTE: Filter dryers are not needed on chillers which make use of a purge system.
****

Chiller refrigerant circuit must be completely piped and factory leak tested in accordance with ANSI/ASHRAE 15 & 34.[For multicompressor units, not less than two independent refrigerant circuits must be provided.] Circuit must include as a minimum a[combination filter and drier,] combination sight glass and moisture indicator, an electronic or thermostatic expansion valve with external equalizer or float valve, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.6.4 Controls Package

****
NOTE: For large water-cooled chillers (centrifugal or rotary screw), motor starters and disconnects switches which are to be remotely-mounted are not

typically supplied by the chiller manufacturer.
****

Provide chillers with a complete[factory-mounted][remote-mounted where indicated], microprocessor based operating and safety control system. Controls package must contain as a minimum a digital display, an on-auto-off switch,[motor starters,][variable frequency motor controller,][disconnect switches,] power wiring, and control wiring. Controls package must provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and [BAS] [UMCS] interfaces as defined below.

2.6.4.1 Operating Controls

****
NOTE: For proper startup and head pressure controls, enter the winter design temperature to which the equipment will be subjected. Coordinate this temperature with manufacturers to assure available equipment.

A cooling tower bypass line and modulating control valve should be evaluated and incorporated into a design which requires chiller operation in ambient temperatures less than 13 degrees C 55 degree F.
****

Chiller must be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer or automated controls to prevent a compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multi-compressor units

d. Load limiting

e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls must automatically re-cycle the chiller on power interruption.

[f. Startup and head pressure controls for air-cooled condensers to allow system operation at all ambient temperatures down to [_____] degrees C F.

][g. Fan sequencing for air-cooled condenser

][h. Start-up and head pressure controls for water-cooled condensers to allow system operation down to [_____] degrees C F entering condenser water temperature.

]2.6.4.2 Monitoring Capabilities

During normal operations, the control system must be capable of monitoring and displaying the following operating parameters. Access and operation of display must not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. [Entering and leaving chilled water pressure][Chilled water flow]

c. [Entering and leaving condenser water pressure][Condenser water flow]

d. Self diagnostic

e. Operation status

f. Operating hours

g. Number of starts

h. Compressor status (on or off)

i. Compressor load (percent)

j. Refrigerant discharge and suction pressures

k. Magnetic bearing levitation status (if applicable)

l. Magnetic bearing temperatures (if applicable)

m. Oil pressure (if applicable)

[n. Condenser water entering and leaving temperatures

][o. Number of purge cycles over the last 7 days

]2.6.4.3 Configurable Setpoints

****
NOTE: Small sized chillers may not have security setting capabilities.
****

The control system must be capable of being configured directly at the unit's interface panel.[No parameters may be capable of being changed without first entering a security access code.] The programmable setpoints must include the following as a minimum:

a. Leaving Chilled Water Temperature

[b. Leaving Condenser Water Temperature

][c. Time Clock/Calendar Date

]2.6.4.4 Safety Controls with Manual Reset

****
NOTE: Conventional compressors with oil-lubricated bearings will require low oil flow protection.
****

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection

b. High condenser refrigerant discharge pressure protection

c. Low evaporator pressure protection

d. Chilled water flow detection

e. High motor winding temperature protection

f. Low oil flow protection (if applicable)

g. Magnetic bearing controller (MBC), Internal fault (if applicable)

h. MBC, High bearing temperature (if applicable)

i. MBC, Communication fault (if applicable)

j. MBC, Power supply fault (if applicable)

[k. Motor current overload and phase loss protection

]2.6.4.5 Safety Controls with Automatic Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection

b. Chilled water flow interlock

c. MBC, Vibration (if applicable)

d. MBC, No levitation (if applicable)

[e. Phase reversal protection

]2.6.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system must be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor must provide an alarm circuit (including transformer if applicable) and a minimum 100 mm 4 inch diameter alarm bell. Alarm circuit must activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell must not sound for a chiller that uses low-pressure cutout as an operating control.

2.6.4.7 Utility Monitoring and Control System Interface

Provide a Utility Monitoring and Control System (UMCS) interface meeting the requirements of Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and the requirements of[Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][or][Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]. The interface must provide all system operating conditions, capacity controls, and safety shutdown conditions as network points. In addition, the following points must be overridable via the network interface:

a. Unit Start/Stop

[b. Leaving Chilled Water Temperature Setpoint

][c. Leaving Condenser Water Temperature Setpoint

]2.6.5 Compressor(s)

****

Note: Reciprocating compressors are used by very few manufacturers, typically for special applications such as refrigeration. Efficiency and production costs have pushed most comfort cooling application manufacturers to scroll compressors. Reciprocating compressors for refrigeration applications are specified in Sections 23 63 00.00 COLD STORAGE REFRIGERATION SYSTEMS and 23 69 00.00 20 REFRIGERATION EQUIPMENT FOR COLD STORAGE.

****

2.6.5.1 Scroll Compressor(s)

****

Note: Designer must consider unloading for more precise leaving water temperature control. Also, chiller manufacturers recommend minimum system volumes to prevent short-cycling of the chiller(s) to promote long chiller life and good chilled water temperature control, especially in smaller chilled water systems. In small systems it may be necessary to install an inertia tank in the chilled water loop to achieve the required minimum system volume. Check the requirements of the chiller manufacturer and provide an insulated inertia tank of sufficient volume when required. Install the chilled water storage tank downstream of the chiller and upstream of the cooling coils. The designer should provide calculations to demonstrate compliance with this requirement. Volumes for components may be estimated where manufacturer's data is not available.

****

Compressors must be of the hermetically sealed design. Compressors must be mounted on vibration isolators to minimize vibration and noise. Rotating parts must be statically and dynamically balanced at the factory to minimize vibration. Lubrication system must be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater must be provided.[Provide continuous compressor unloading to[10 percent][15 percent] of full-load capacity by way of variable speed compressor motor controller or variable unloading of the scroll.]

2.6.5.2 Rotary Screw Compressor(s)

****

NOTE: If an open drive (air cooled) motor is used, provide mechanical ventilation if required to reject the additional heat added to the space at the source. The additional mechanical ventilation

should be counted into the efficiency calculations for the chiller.

****

Compressors must operate stably for indefinite time periods to at least 25 percent capacity reduction without gas bypass external to the compressor. Provision must be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors must include:

a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Allow access to internal compressor components for repairs, inspection, and replacement of parts.

b. Rotors must be solid steel, possessing sufficient rigidity for proper operation.

c. A maximum rotor operating speed no greater than 3600 RPM. Provide cast iron rotor housing.

d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors with minimal clearance at rotor tops and rotor ends.

e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

f. Bearing housing must be conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11.

g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.

h. [A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 15 percent.][Use a Variable Frequency Drive (VFD) to modulate capacity modulation from 100 percent to 15 percent.]

i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.

j. Crankcase oil heaters must be provided.

2.6.5.3 Centrifugal Compressor(s)

****

NOTE: Conventional compressors will require provisions to ensure proper lubrication of bearings.

When centrifugal chillers are used for heat recovery duty, the entering heat recovery condenser water temperature is usually controlled to between 35 and 40 degrees C 95 and 105 degrees F so that the water

temperature leaving the heat recovery condenser is high enough to be used as a heat source. Under these conditions, the chiller will be operating at a higher head pressure than normally encountered. At these high head conditions, the centrifugal compressor may surge at part-load conditions of as high as 30 percent to 40 percent depending upon the conditions to which the chiller is subjected. In these cases, the designer should survey the manufacturers to determine at what load the available chillers will surge, at the conditions and loads to be encountered at the site. The bracketed sentences will be removed from the centrifugal chiller paragraph and replaced with the appropriate capacity control requirements. The designer should also consider multiple chillers to satisfy the load and to partition the loading to the chillers such that the heat recovery chiller load is sufficiently high to avoid surge. When examining heat recovery, full consideration should be given to the effect of 35-40 degrees C 95-105 degree F water and the resulting power requirements of the chiller on the economic benefit of heat recovery.

If an open drive (air cooled) motor is used, provide mechanical ventilation if required to reject the additional heat added to the space at the source. The additional mechanical ventilation should be counted into the efficiency calculations for the chiller.
****

Centrifugal compressors may be either single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers must be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft must be steel with sufficient rigidity for proper operation at any required operating speed. Compressors must be capable of variable speed operation and may have either oil-free bearing drives or oil-lubricated bearing drives. Centrifugal compressors must include:

a. Shaft main bearings that are either oil lubricated, oil free ceramic or magnetic levitated. The oil lubricated bearings must be the rolling element type in accordance with ABMA 9 or ABMA 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Oil lubricated or oil free ceramic bearings must be rated for an L(10) life of not less than 200,000 hours. Magnetic levitated main shaft bearings must be in accordance with ISO 14839-1, ISO 14839-2, ISO 14839-3, ISO 14839-4, and provided with radial and axial magnetic levitated bearings (combination permanent and electro magnets) to levitate the shaft thereby eliminating metal to metal contact and thus eliminating the need for oil. The active magnetic bearings must be equipped with an automatic vibration reduction and balancing system. Each bearing position must be sensed by position sensors and provide real time positioning of the rotor shaft, controlled by on-board digital electronics. In the event of a power failure, the magnetic bearings must remain in operation throughout the compressor coast-down using a reserve power supply. Provide mechanical bearings designed for emergency touchdowns, as a backup to the magnetic bearings.

b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.

c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply (if applicable). On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment must allow the compressor to operate only when the required oil pressure is provided to the bearings (if applicable).

e. Oil sump heaters controlled as recommended by the manufacturer.

f. Temperature-or pressure-actuated pre-rotation vane, variable geometry diffuser or suction damper to provide automatic capacity modulation from 100 percent capacity to 25 percent capacity. If operation to 25 percent capacity cannot be achieved without providing gas bypass external to the compressor, then the Contractor must indicate in the equipment submittal the load percent at which external hot gas bypass is required to prevent surge and to provide the specified capacity reduction and its impact on performance.

2.6.6 Compressor Driver, Electric Motor

****

NOTE: If an open drive (air cooled) motor is used, provide mechanical ventilation if required to reject the additional heat added to the space at the source. The additional mechanical ventilation should be counted into the efficiency calculations for the chiller.

****

Components such as motors,[starters,][variable speed drives,] and wiring must be in accordance with paragraph ELECTRICAL WORK. [Motor starter][Variable frequency drive]must be[unit mounted][remote mounted] as indicated with[starter][variable frequency drive] type, wiring, and accessories coordinated with the chiller manufacturer.

2.6.7 Compressor Driver, Gas-Engine

****

NOTE: Natural gas-engine drives are used in conjunction with either reciprocating, rotary, or centrifugal type compressors.

Before considering natural gas chillers, consider federal Executive Order 14057. In addition, compliance with DoD and each applicable service agency electrification policy is required.

The decision to use a heavy duty industrial type engine as compared to a standard automotive type engine will be based strictly on an economic

comparison. The standard automotive type engines have a much lower initial cost, but they must be replaced or overhauled much more often. Also note that typically, standard automotive type engines are only available for chillers with a capacity of 1760 kW 500 tons or less.

Guidance to Project Designers: When specifying natural gas-engine drive chillers, close coordination with the DPW (customer) must be exercised. The designer should inform the DPW that preventive maintenance and periodical overhaul of the gas-engine drives is essential to ensure continued operation, and that energy demand savings are realized. While the initial cost of gas-engine drives is much lower than other types, gas-engine drives require more frequent maintenance and overhaul.

****

Gas-engine compressor driver must operate on natural gas and be in accordance with NFPA 37 and NFPA 54. Engine must be designed for stationary applications and include all ancillaries necessary for operation. Engine must be a manufacturer's standard production model and be specifically designed for chiller operation. Engine must include as a minimum a[heavy duty industrial][standard automotive] grade block, starting system, lubrication system, coolant system, engine heat exchanger,[engine cooling radiator,] fuel supply system, electronic ignition, and controls package. Engine must be either[naturally aspirated,][supercharged,][or][turbocharged] and include appropriate air filters. Engine must be 2- or 4-stroke-cycle and compression-ignition type. Engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. Engine must have a minimum of 2 cylinders. Opposed-piston type engines must have not less than 4 cylinders. Engine block must have a coolant drain port.

2.6.7.1 Starting System

****

NOTE: Specify either an electric or pneumatic type starting system. Electric type system will be used for most applications. For installations where a compressed air system exists or is to be installed, a pneumatic starting system should be considered.

For pneumatic start systems size air receiver tank and compressor per manufacturer's recommendations.

****

Engine starting system must be either the[electric][pneumatic] type and be of sufficient capacity, at the maximum temperature specified, to crank the engine without damage or overheating.[Electric starting system must operate on a [24][_____]-volt DC system utilizing a negative circuit ground. A starting battery system must be provided and must include the battery, corrosion resistant battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Battery must be in accordance with SAE J537. Battery charger must conform to UL 1236 and be the current-limiting type with overcurrent protection.][Pneumatic starting system must be as specified in Section

22 00 00 PLUMBING, GENERAL PURPOSE, for a working pressure of 1.03 MPa 150 psi.]

2.6.7.2   Lubrication System

Engine must be provided with a pressurized oil lubrication system. System must include a lubrication oil pump that is engine driven. One full-flow filter must be provided for each pump. Filters must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. System pressure must be regulated as recommended by the engine manufacturer. A pressure relief valve must be provided on the crankcase. Crankcase breathers must be piped to the outside. System must be readily accessible for servicing such as draining, refilling, and overhauling.

2.6.7.3   Coolant System

Engine must include an automatic engine jacket water cooling system. Water must be circulated through the system with an engine-driven circulating pump.[System coolant must use a combination water and ethylene-glycol sufficient for freeze protection at the minimum temperature specified.]

[2.6.7.4   Engine Heat Exchanger

****

NOTE: If engine heat exchanger is used the cooling tower must be sized to include heat rejected from both engine and chiller.

****

Engine heat exchanger must be of the shell-and-tube type construction and be in accordance with ASME BPVC SEC VIII D1. Shell material must be carbon steel. Tubes must be seamless copper or copper-nickel. Tubes must be individually replaceable. Unit's waterside working pressure must be rated for not less than 1,000 kPa 150 psig and factory tested at 150 percent of design working pressure. Water connections larger than 75 mm 3 inches must be ASME Class 1500 flanged. Unit must be provided with gasketed removable covers, drains, and vents.

][2.6.7.5   Engine Cooling Radiator

****

NOTE: An engine cooling radiator will be needed to satisfy an engine's cooling requirements if cooling tower water or heat recovery is not used.

****

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces must be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers must be the pressure type incorporating a pressure valve, vacuum valve and a cap. Caps must be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system must be capable of withstanding a minimum pressure of 48 kPa 7 psi and must be protected with a strong grille or screen guard. Each heat exchanger must have at least 2 tapped holes; one must be equipped with a drain cock, the rest must be plugged.

]2.6.7.6 Fuel Supply System

Engine fuel supply system must be factory mounted. System must include as a minimum a solenoid shut-off valve, a gas pressure regulator, and carburetors (including a throttle body assembly) or fuel injectors.

2.6.7.7 Controls Package

The controls for the gas-engine must be incorporated into the overall controls package for the water chiller. The engine controls must be capable of monitoring, displaying, and controlling, as applicable, the following conditions. The control system must be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data must include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system must also be capable of receiving at a minimum the following operating conditions:

a. Coolant-fluid inlet and outlet temperatures

b. Lubricating-oil inlet and outlet temperatures and pressures

c. Engine run-time hours

d. Engine current status mode (on/off)

e. Engine speed

f. Percent engine load

g. Engine jacket temperature

2.6.7.8 Exhaust Piping

Exhaust piping must be ASTM A53/A53M Schedule 40 seamless black iron, exhaust piping installation must be per the engine manufacturer's recommendations, except as modified herein. Horizontal sections of exhaust piping must be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction must be long radius. Exhaust piping and mufflers must be insulated in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Vertical exhaust piping must be provided with a hinged, gravity-operated, self-closing, rain cover.

2.6.7.9 Exhaust Muffler

Engine must be provided with a chamber type exhaust muffler. The muffler must be of welded steel and designed for[outside][inside][vertical][horizontal] mounting. Eyebolts, lugs, flanges, or other items must be provided as necessary for support in the location and position indicated. Pressure drop through the muffler must not exceed the recommendations of the engine manufacturer. Outside mufflers must be zinc coated or painted with high temperature[[_____] degrees C degrees F] resisting paint. The muffler and exhaust piping together must reduce the noise level to less than [_____] dBa at a distance of 22.9 m 75 feet from the end of the exhaust piping with the chiller operating at 100 percent of rated output capacity. The muffler must have a drain valve, nipple, and cap at the low-point of the muffler.

2.6.7.10   Exhaust System Connections

Flexible connectors must be provided at the exhaust piping connection to the engine. An expansion joint must be provided in the exhaust piping at the muffler connection. Flexible connectors and expansion joints must have flanged connections. Flexible sections must be made of convoluted seamless tube without joints or packing. Expansion joints must be the bellows type. Expansion and flexible elements must be stainless steel suitable for engine exhaust gas at 649 degrees C 1200 degrees F. Flexible connectors and expansion joints must be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.6.8   Compressor Driver Connections

****

NOTE: Delete the first set of brackets if a large water-chilling package is specified. Delete the second set of brackets if a condensing and compressing unit or a small water-chilling package is used.

****

[Each compressor must be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives must be designed for not less than 150 percent of the driving motor capacity. Flexible couplings must be of the type that does not require lubrication.][Each machine driven through speed-increasing gears must be so designed as to assure self-alignment, interchangeable parts, proper lubrication system, and minimum unbalanced forces. Bearings must be of the sleeve or roller type. Gear cases must be oil tight. Shaft extensions must be provided with seals to retain oil and exclude all dust.]

2.6.9   Water Cooler (Evaporator)

****

NOTE: Confirm the current standard fouling factor with AHRI.

****

Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on a water velocity not less than0.91 m/s 3 fps nor more than 3.7 m/s 12 fps and a fouling factor per AHRI 550/590 I-P.

Brazed plate heat exchanger must be constructed of 304 or 316 stainless steel, designed to a refrigerant-side working pressure of 3,000 kPa 430 psig and a waterside working pressure of 1,000 kPa 150 psig. Evaporator must be factory tested at 1.1 times maximum allowable refrigerant side working pressure and 1.5 times maximum allowable water side working pressure.[Provide cooler heaters to protect the evaporator to an ambient of minus 29 degrees C minus 20 degrees F.] Provide cooler with factory-installed flow switches. All water connections must use either flanged or grooved-pipe connections. Factory insulate all cold surfaces.

2.6.10 Air-Cooled Condenser Coil

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NOTE: Standard coil construction is copper tubes with aluminum fins. For excessively corrosive atmospheres, either copper tubes with copper fins or aluminum tubes with aluminum fins should be considered. For additional corrosion protection, specify the manufacturer's standard epoxy or vinyl coating.

****

[Condenser coil must be of the extended-surface fin-and-tube type and must be constructed of seamless[copper][or][aluminum] tubes with compatible[copper][or][aluminum] fins. Fins must be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils must be circuited and sized for a minimum of 3 degrees C 5 degrees F subcooling and full pump-down capacity. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.][The condenser coil must be of the microchannel heat exchanger technology (MCHX) type consisting of a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds in a two-pass arrangement. Provide coils constructed of aluminum alloys for fins, tubes, and manifolds. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.]

[Coil must be entirely coated in accordance with the requirements of paragraph COIL CORROSION PROTECTION.

]2.6.11 Water-Cooled Condenser Coil

****

NOTE: Confirm the current standard fouling factor with AHRI.

If current data supports the use of river/lake water for cooling tower operation and historic data proves it to be beneficial to the system and proves to be more resilient and economically superior, then the use of lake/river water may be considered. Ultimately, the engineer designing the system should obtain all of the data and make the decision in coordination with the stakeholders.

****

Condenser must be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than [1,000][1,700][2000] kPa [150][250][300] psi. Condensers must be complete with refrigerant relief valve/rupture disc assembly, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser must be provided with a purging device to purge non-condensibles trapped in the condenser while keeping refrigerant emissions below requirements of ASHRAE Std 147. Purge units must be certified per AHRI 580.

Condenser shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on water velocities not less than 0.91 m/s 3 fps nor more than 3.7 m/s 12 fps and a fouling factor per AHRI 550/590 I-P. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for single packaged systems.

2.6.12 Heat Recovery Condenser Coil

****

NOTE: The designer will conduct feasibility studies to determine if a heat recovery condenser is an economical addition to the system. Heat recovery condensers generally come in two sizes. The smaller of the two is generally sized to reject the superheat to the domestic water. The larger is sized to reject the same amount of heat as the standard condenser. The drawings will indicate the heat rejection capacity of the heat recovery condenser and the temperatures of the water to which it must reject the heat.

****

Condenser must be of the shell-and-coil or shell-and-tube type design and must not be a part of the standard condenser. Condenser must be provided and installed by the chiller manufacturer. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than [1,000][1,700][2000] kPa [150][250][300] psi. Condenser must have performance characteristics as indicated on the drawings. Condenser shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on water velocities not less than 0.91 m/s 3 fps nor more than 3.7 m/s 12 fps and a fouling factor per AHRI 550/590 I-P.

2.6.13 Receivers

Receiver must bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and must meet the requirements of ANSI/ASHRAE 15 & 34. Inner surfaces must be thoroughly cleaned by sandblasting or other approved means. Each receiver must have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver must be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ANSI/ASHRAE 15 & 34, and two bull's eye liquid-level sight glasses. Sight glasses must be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 75 mm 3 inches horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.6.14 Chiller Purge System

****

NOTE: Refrigeration systems which operate below atmospheric pressure (i.e., R-123 machines) will require a refrigerant purge piping system. Indicate the routing of the piping on the drawings. Require the Contractor to delete the piping if a purge system is not required for the type of chiller that is to be provided. Indicate that it will be the Contractor's responsibility to size the piping based upon the chiller manufacturer's recommendations. Purge discharge piping may be connected to the pressure-relief piping on the chiller side of the piping's vibration isolators.

****

Chillers which operate at pressures below atmospheric pressure must be provided with a purge system. Purge system must automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant while keeping refrigerant emissions below requirements of ASHRAE Std 147. Purge units must be certified per AHRI 580. Purge system must condense, separate, and return all refrigerant back to the chiller. An oil separator must be provided with the purge system if required by the manufacturer. Purge system must not discharge to occupied areas, or create a potential hazard to personnel. Purge system must include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system must include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

2.6.15 Tools

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NOTE: Tools to be used for Army projects only.

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One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, must be provided. Tools must be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.7 ACCESSORIES

2.7.1 Refrigerant Leak Detector

****

NOTE: Refrigerant leak detectors will be provided as required by the "System Application Requirements" in ASHRAE 15.

When a detector is required, the location will be indicated on the drawings. Detectors are best located between the refrigeration system and the room exhaust. Sampling points from a detector will be located a maximum of 460 mm 18 inches above the finished floor since all commonly-used refrigerants are heavier than air.

As a rule of thumb, the distance between any refrigeration system and a refrigerant sampling point should not exceed 15.24 m 50 feet. In order to meet the recommended 15.24 m 50 foot distance, a mechanical room can be provided with either multiple detectors each with single sampling points or with one detector that has the capability of monitoring at multiple sampling points. If multiple sampling points are required, enter the number in the appropriate blank below.

Per ASHRAE 15, when a detector senses refrigerant it must activate an alarm and initiate the room ventilation system. In regards to alarms, as a minimum, indicate that the detector will energize a light on or near the detector as well as a second light installed on the outside wall next to the mechanical room entrance. The exterior light will be provided with a sign that warns personnel entering the mechanical room of a refrigerant release and that a SCBA is required to enter. If applicable to the installation, include an audible alarm on the exterior of the mechanical room. Include the electrical design for the alarm system on the drawings.

As an additional item, ASHRAE 15 states that open-flame devices such as boilers cannot be installed in the same area as a refrigeration system, unless either combustion air for the open-flame device is ducted straight from outside to the device; or the alarm relay from the detector is used to automatically shutdown the combustion process in the event of refrigerant leakage. Indicate all applicable alarm controls on the drawings.

The last bracketed sentence in the paragraph below is for Army projects only. Delete the information in the last bracketed sentences if a Building Control Network (BCN) is not applicable to the design.
****

Detector must be the continuously-operating, halogen-specific type. Detector must be appropriate for the refrigerant in use. Detector must be specifically designed for area monitoring and must include[a single sampling point][[_____] sampling points] installed where indicated. Detector design and construction must be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector must have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector must be supplied factory-calibrated for the appropriate refrigerant(s). Detector must be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay must be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector must be provided with a failure relay output that energizes when the monitor detects a fault in its operation.[Detector must be compatible with the facility's Building Control Network (BCN). The BCN must be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.]

2.7.2 Refrigerant Relief Valve/Rupture Disc Assembly

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NOTE: ASHRAE 15 requires refrigeration systems to be protected with a pressure-relief device that will safely relieve pressure due to fire or other abnormal conditions. A relief valve/rupture disc assembly is the optimum solution. The rupture disc will provide visual indication of a release while also providing immediate shutoff once a safe pressure is achieved.

Designer will indicate on the drawings the location of each new relief valve/rupture disc assembly as well as the routing and size of corresponding pressure-relief piping. The routing and size of new pressure-relief piping will be per ASHRAE 15.

****

The assembly must be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly must be in accordance with ASME BPVC SEC VIII D1 and ANSI/ASHRAE 15 & 34. The assembly must be provided with a pressure gauge assembly that provides local indication if a rupture disc is broken. Rupture disc must be the non-fragmenting type.

2.7.3 Refrigerant Signs

Refrigerant signs must be a medium-weight aluminum type with a baked enamel finish. Signs must be suitable for indoor or outdoor service. Signs must have a white background with red letters not less than 13 mm 0.5 inches in height.

2.7.3.1 Installation Identification

Each new refrigerating system must be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.7.3.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg 110 lb of refrigerant must be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow[, the ventilation system,] and the refrigerant compressor(s).

b. Pressure limiting device(s).

[2.7.4 Automatic Tube Brush Cleaning System

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NOTE: Delete this paragraph unless specifically required by the onsite staff.

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2.7.4.1 Brush and Basket Sets

One brush and basket set (one brush and two baskets) must be furnished for each condenser tube. Brushes must be made of nylon bristles, with titanium wire. Baskets must be polypropylene.

2.7.4.2 Flow-Diverter Valve

Each system must be equipped with one flow-diverter valve specifically designed for the automatic tube brush cleaning system and have parallel flow connections. The flow-diverter valve must be designed for a working pressure of [1,000][1,700][2000] kPa [150][250][300] psig. End connections must be flanged. Each valve must be provided with an electrically operated air solenoid valve and position indicator.

2.7.4.3 Control Panel

The control panel must provide signals to the diverter valve at a preset time interval to reverse water flow to drive the tube brushes down the tubes and then signal the valve to reverse the water flow to drive the brushes back down the tubes to their original position. The controller must have the following features as a minimum:

a. Timer to initiate the on-load cleaning cycle.

b. Manual override of preset cleaning cycle.

c. Power-on indicator.

d. Diverter-position indicator.

e. Cleaning-cycle-time adjustment

f. Flow-switch bypass.

]2.7.5 Gaskets

Gaskets must conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C 700 degrees F service.

2.7.6 Bolts and Nuts

Bolts and nuts, except as required for piping applications, must be in accordance with ASTM A307. The bolt head must be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.8 FABRICATION

2.8.1 Factory Coating

****

NOTE: For equipment to be installed outdoors, adequate protection must be specified. Manufacturers must submit evidence that unit specimen have passed the specified salt spray fog test. A 125 hour test must be specified in a noncorrosive environment and a 500 hour test will be specified in a corrosive environment.

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Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that withstands [125][500] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.8.2 Factory Applied Insulation

Chiller must be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it must be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by ASTM E84. Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

[2.8.3 Coil Corrosion Protection

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NOTE: Research local conditions to determine the corrosiveness of the environment. Where condenser or evaporator coils are exposed to corrosive atmospheres such as seacoast applications, carefully consider the coil and fin combinations specified. Standard coil construction is typically copper tubes with aluminum fins. For more corrosive

environments, either copper tubes with copper fins or aluminum tubes with aluminum fins should be considered.

For maximum coil protection, include the requirements of this paragraph. This paragraph addresses phenolic, vinyl, and epoxy type coatings. For coils with relatively close fin spacing the phenolic or epoxy coating are the preferred types as these have less tendency to bridge across the fins than vinyl. In addition, the phenolic and epoxy type coatings can typically provide better thermal conductivity than vinyl.

If coatings are specified, note that a coil's heat transfer capacity can be reduced anywhere between 1 to 5 percent; total unit capacity may have to be increased as a result. Provide coil coatings with 3,000 hour salt spray compliance for seacoast installations.

****

Provide coil with a uniformly applied[epoxy electrodeposition][phenolic][vinyl] type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation. Coating must be capable of withstanding a minimum [1,000][3,000] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

]2.9 FACTORY TESTS

2.9.1 Chiller Performance Test

****

NOTE: Currently, most chiller manufacturers do not have the ability to factory performance test anything other than water-cooled chillers (centrifugal or rotary screw) which have flooded evaporators. In addition, most testing facilities are only setup to test chillers 1054 kW 300 tons or larger in capacity. The ability to performance test small DX systems (water- or air-cooled) is almost non-existent.

Chiller performance testing is a very expensive requirement and should be carefully evaluated before including it into a job specification. The AHRI certification program has gone a long way in recent years of assuring chiller performance as specified. The need for a performance test will be evaluated against the customer's requirements and the criticality of the installation. When a chiller performance test is not required, ensure that paragraph SUBMITTALS is edited to remove the requirements for factory tests in SD-03 and SD-06.

If a performance test is deemed necessary to assure that the capacity and efficiencies specified will be met, then include this paragraph. Testing should only be specified on water-cooled chillers between 1054 and 5622 kW 300 and 1600 tons. Tests may be specified for smaller chillers in critical applications where the tests are felt justified, however, the designer must determine in the design stage if such tests are available. In no case should a test be required on more than one unit of multiple, identical capacities.

The AHRI testing of chillers allows a deviation to chiller capacity of up to 5 percent at full load. Load calculations should consider this tolerance.

****

The Contractor and proposed chiller manufacturer must be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, and[IPLV][NPLV] in accordance with AHRI 550/590 I-P except as indicated. The Contractor and chiller manufacturer must provide to the Government a certified chiller factory test report in accordance with AHRI 550/590 I-P to confirm that the chiller performs as specified. Tests must be conducted in an AHRI certified test facility in conformance with AHRI 550/590 I-P procedures and tolerances, except as indicated. At a minimum, chiller capacity must be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation must be in strict accordance with AHRI 550/590 I-P. Stable operation at minimum load of [10][_____] percent of total capacity must be demonstrated during the factory test.

2.9.1.1 Temperature Adjustments

Temperature adjustments must adhere to AHRI 550/590 I-P to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments must be verified prior to testing by the manufacturer. There must be no exceptions to conducting the test with clean tubes with the temperature adjustments per AHRI 550/590 I-P. The manufacturer must clean the tubes prior to testing to obtain a test fouling factor of 0.0000.

2.9.1.2 Test Instrumentation

The factory test instrumentation must be per AHRI 550/590 I-P and the calibration must be traceable to the National Institute of Standards and Technology.

2.9.1.3 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer must be allowed to make necessary revisions to his equipment and retest as required.[The manufacturer must assume all expenses incurred by the Government to witness the retest.]

[2.9.2 Chiller Sound Test

****

NOTE: Require factory sound tests for chiller applications where sound levels are a critical

issue. Typically, factory sound tests are only performed on large centrifugal and rotary screw machines. As a minimum if a factory sound test is not deemed necessary, indicate the maximum allowable sound level requirements for all applicable chiller components on the drawings.

In the paragraph below, select 85 decibels if military personnel (90 decibels for civilian personnel) will operate the equipment without hearing protection. Other decibel requirements may be specified if hearing protection is provided.

****

Chillers must be sound tested at the factory prior to shipment to confirm the sound pressure level specified herein. Tests and data must be conducted and measured in strict accordance with AHRI 575 at the full load system operating conditions. The chiller sound pressure level, in decibels (dB), with a reference pressure of 20 micropascals, must not exceed [85][90][_____] dB, A weighted. Ratings must be in accordance with AHRI 575. No reduction of entering condenser water temperature or raising of leaving chilled water temperature is allowed. A minimum of 75 percent of the sound data points must be taken along the length of the machine, and established as the minimum percentage of total possible points used to determine sound levels. In the event that the chiller does not meet the dBA sound pressure level, the manufacturer must, at his expense, provide sufficient attenuation to the machine to meet the specified value. This attenuation must be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller. The attenuation material, adhesives, coatings, and other accessories must have surface burning characteristics as determined by ASTM E84.

]2.10 SUPPLEMENTAL COMPONENTS/SERVICES

2.10.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories must be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.10.2 Refrigerant Piping

Refrigerant piping for split-system water chillers must be provided and installed in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.10.3 Cooling Tower

Cooling towers must be provided and installed in accordance with Section 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.

2.10.4 Temperature Controls

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NOTE: Modify this paragraph as required to coordinate the central equipment controls with the air-side system controls. In projects where this section of the specifications is intended to produce control equipment for existing air-side systems, this paragraph will be rewritten to secure controls

to match existing controls and to properly integrate the specified controls into the existing temperature control system.

A sequence of control, a schematic of controls, and a ladder diagram should be included on the drawings for each major system component such as cooling tower fan, chilled water pump, condenser water pump, in order to define the overall system operation.
****

Chiller control packages must be fully coordinated with and integrated[into the temperature control system indicated in Section 23 30 00 HVAC AIR DISTRIBUTION and[Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][and][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][or][Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]][into the existing air-conditioning system].

PART 3 EXECUTION

3.1 INSTALLATION

Installation of water chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with the manufacturer's written installation instructions, including the following:

[(1) Water chiller - installation instructions

]3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least [5][_____] weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions, and start-up procedures and checklists. Data must be adequate to demonstrate compliance with contract requirements.

All recommendations stated in the installation instructions or other similar manufacturer's published literature must be considered mandatory and part of the contract documents. Any discrepancies to the engineered drawings and specifications must be brought to the attention of the COR.

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 Posted Instructions

Provide posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

3.1.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.5 System Performance Test Schedules

Provide a schedule, at least [2][_____] weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.6 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, AHRI, ANSI/ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard AHRI rating conditions, computer printouts, catalog, or other application data certified by AHRI or a nationally recognized laboratory as listed in this Certificates section must be included. If AHRI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.1.7 Operation and Maintenance Manuals

Provide [six][_____] complete copies of an operation manual in bound 216 by 279 mm 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4][_____] weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. [Six][_____] complete copies of maintenance manual in bound 216 by 279 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.8 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.9 Refrigeration System

3.1.9.1 Equipment

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NOTE: Determine in the initial stages of design the approximate distances required for maintenance clearances of all new equipment. The maintenance clearances will be used in determining the final layout of the equipment.

For installations where noise and vibration transmission to the building must be reduced, the maximum tolerable transmissibility, in percent, should be determined and the blank filled in with the appropriate value. When it is not necessary to specify the percent of transmissibility, the item in the brackets will be deleted and brackets removed. Recommended transmissibility in percentages are: 10 percent for equipment mounted in very critical areas; 10 to 20 percent for critical areas; and 20 to 40 percent for noncritical areas. The drawings should be checked to ensure that all structural and equipment connection factors and the conditions surrounding the equipment to be provided with the vibration isolation units favorably influence the effectiveness of the isolators. Where many items of equipment require different transmission values, based on the equipment location, the specification may be revised to indicate the appropriate values on the drawings.

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Refrigeration equipment and the installation thereof must conform to ANSI/ASHRAE 15 & 34. Necessary supports must be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, water coolers, and similar items. Compressors must be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations must be provided. Each foundation must include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment must be set on not less than a 150 mm 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps must have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block must be of mass not less than three times the combined pump, motor, and base weights. Isolators must be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators must limit vibration to [_____] percent at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks must be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts must be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions. All recommendations stated in the installation instructions or other similar manufacturer's published literature must be considered mandatory and part of the contract documents. Any discrepancies to the engineered drawings and specifications must be brought to the attention of the COR.

3.1.9.2   Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system must be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor must provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system must be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points must be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must immediately be isolated from the remainder of the system and the refrigerant must be pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor must, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps must include, but not be limited to, procedures that minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time must more than 85 g 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.9.3   Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase must be furnished. One charge must be used during the performance testing period, and upon the satisfactory completion of the tests, the oil must be drained and replaced with the second charge.

[3.1.10   Mechanical Room Ventilation

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NOTE: For mechanical rooms which are intended to house refrigeration equipment, designers will use ASHRAE 15 to determine applicable design criteria. Delete this paragraph if a mechanical room is not applicable to the design.
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Mechanical ventilation systems must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

]3.1.11 Field Applied Insulation

Field installed insulation must be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.12 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 FACTORY TEST SCHEDULING AND REPORTS

Provide Factory Test Schedule which identify the date, time, and location for each test. Schedules must be submitted for the Chiller Performance Tests[and the Chiller Sound Test].[The Chiller Performance Test schedule must also allow the witnessing of the test by a Government Representative.]

[Six][_____] copies of the certified test report must be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation must be included. Provide copies in bound 216 by 279 mm 8 1/2 by 11 inch booklets. Reports must certify the compliance with performance requirements and follow the format of the required testing standard for the Chiller Performance Tests[and the Chiller Sound Tests]. Test report must include certified calibration report of all test instrumentation. Calibration report must include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report must be submitted [1][_____] week after completion of the factory test.

3.3 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative must be provided for overseeing of the installation, start-up, and initial operation of the chiller including field acceptance testing. The representative must advise on the following:

a. Hermetic machines:

    (1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 micrometers.

    (2) Charging the machine with refrigerant.

    (3) Starting the machine.

b. Open Machines:

    (1) Erection, alignment, testing, and dehydrating.

    (2) Charging the machine with refrigerant.

    (3) Starting the machine.

3.4 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers must be cleaned in accordance with the chiller manufacturer's instructions. All recommendations stated in the installation instructions or other similar manufacturer's published literature must be considered mandatory and part of the contract documents. Any discrepancies to the engineered drawings and specifications must be brought to the attention of the COR. This work covers two coil cleanings. The condenser coils must be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner must not have any detrimental affect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing must be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5 FIELD ACCEPTANCE TESTING

3.5.1 Test Plans

a. Manufacturer's Test Plans: Within [120][_____] calendar days after contract award, submit the following plans:

[(1) Water chiller - Field Acceptance Test Plan

Field acceptance test plans must be developed by the chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, is not acceptable.

The Contracting Officer must review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the chiller and subsequent test reporting.

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NOTE: In the paragraph below, specification Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS are for Navy projects only.

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b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under [Section 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][or][Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

c. Prerequisite testing: Chillers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controller must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer must identify the acceptable limits or tolerance within which each tested performance variable must acceptably operate.

f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.5.2 Testing

a. Each water chiller system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

[(1) Water chiller - Field Acceptance Test Report

] b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed must result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.6 SYSTEM PERFORMANCE TESTS

All reports must be signed and submitted in electronic format.[In addition, [six][_____] copies of the report must be provided in bound 216 by 279 mm 8 1/2 by 11 inch booklets].

3.6.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment must be conducted by the manufacturer's approved start-up representative experienced in system start-up and testing, at such times as directed. Tests must cover a period of not less than [48][_____] hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments must be made as necessary and tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points must be installed and tightened. Any refrigerant lost during the system startup must be replaced. If tests do not demonstrate satisfactory system performance, deficiencies must be corrected and the system must be retested. Tests must be conducted in the presence of the Contracting Officer. Water and electricity required for the tests must be furnished by the Government. Any material, equipment, instruments, and personnel required for the test must be provided by the Contractor. Field tests must be coordinated with Section 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.6.2 Test Report

The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report must also include the following information and must be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C 5 degrees F apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

    (1) The refrigerant used in the system.

    (2) Condensing temperature and pressure.

    (3) Suction temperature and pressure.

    (4) Running current, voltage and proper phase sequence for each phase of all motors.

    (5) The actual on-site setting of all operating and safety controls.

    (6) Chilled water pressure, flow and temperature in and out of the chiller.

    (7) The position of the[capacity-reduction gear][gas supply control valve][fuel oil supply valve] at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.7 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

Provide a Training Course Schedule, at least [2][_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

-- End of Section --