SECTION 236426 - ROTARY-SCREW WATER CHILLERS

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, single-compressor chillers.
2. Packaged, water-cooled, multiple-compressor chillers.
3. Packaged, air-cooled chillers.
4. Packaged, portable refrigerant recovery units.
5. Heat-exchanger, brush-cleaning system.

B. Related Section:

1. Section 283500 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.3 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 506/110 and referenced to ARI standard rating conditions.

E. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 506/110 and intended for operating conditions other than ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of [**60 deg F (16 deg C)**] [**55 deg F (13 deg C)**] [**40 deg F (4 deg C)**] <**Insert temperature**> and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of [**65 deg F (18 deg C)**] [**60 deg F (16 deg C)**] [**55 deg F (13 deg C)**].
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with the following in lieu of ARI 506/110:

1. Allowable Capacity Tolerance: [**Zero**] <**Insert number**> percent.
2. Allowable IPLV/NPLV Performance Tolerance: [**Zero**] <**Insert number**> percent.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of chiller.
5. Oil capacity of chiller.
6. Fluid capacity of evaporator.
7. Characteristics of safety relief valves.

8. Fluid capacity of condenser[**and heat-reclaim condenser**].
9. Minimum entering condenser-fluid temperature.
10. Performance at varying capacities with constant-design entering condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in [**5 deg F (3 deg C)**] <**Insert temperature**> increments.
11. Minimum entering condenser-air temperature.
12. Maximum entering condenser-air temperature.
13. Performance at varying capacities with constant-design entering condenser-air temperature. Repeat performance at varying capacities for different entering condenser-air temperatures from design to minimum in [**10 deg F (6 deg C)**] <**Insert temperature**> increments.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Startup service reports.

F. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to [**ARI 550**] [**and**] [**ARI 590**] certification program(s).

B. ARI Rating: Rate chiller performance according to requirements in ARI 506/110.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Ship chillers from the factory fully charged with refrigerant.

B. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

C. Ship each oil-lubricated chiller with a full charge of oil.

1. Ship oil [**factory installed in chiller**] [**in containers separate from chiller**].

D. Package chiller for export shipping in totally enclosed [**crate**] [**and**] [**bagging**].

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller including refrigerant and oil charge.
b. Complete compressor and drive assembly including refrigerant and oil charge.
c. Refrigerant [**and oil**]charge.
d. Parts [**only**] [**and labor**].
e. Loss of refrigerant charge for any reason.

2. Warranty Period: [**Two**] [**Three**] [**Four**] [**Five**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED, WATER-COOLED, SINGLE-COMPRESSOR CHILLERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: Factory-assembled and [**run**]-tested chiller with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, [**heat-reclaim condenser as indicated,**]controls, interconnecting unit piping and wiring, and indicated accessories.

1. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.

C. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

D. Compressor:

1. Description: [**Hermetic**] [**or**] [**open**], positive displacement, and oil lubricated.
2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
3. Rotors: Manufacturer's standard one-, two-, or three-rotor design.

4. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
5. Seals: Seal drive assembly to prevent refrigerant leakage.

E. Compressor Motor:

1. Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with [**open-dripproof**] [**weather-protected, Type I**] [**weather-protected, Type II**] [**totally enclosed**] enclosure.
5. Provide motor with thermistor or RTD in [**single motor winding**] [**each of three-phase motor windings**] to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.

F. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

1. Overspeed Test: 25 percent above design operating speed.

G. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

H. Capacity Control: Modulating slide-valve assembly or port unloaders combined with [**a variable frequency controller, if applicable, and**]hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to [**20**] [**15**] [**10**] [**5**] [**zero**] <**Insert number**> percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: [**Constant-design entering condenser-fluid temperature**] [**Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction**] <**Insert conditions**>.

I. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.

3. [**Oil filter**] [**Dual oil filters, one redundant,**] shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
4. [**Refrigerant**] [**Water**] [**Refrigerant- or water**]-cooled oil cooler.
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.

J. Refrigerant Circuit:

1. Refrigerant: Type as indicated on Drawings.
2. Refrigerant Type: [**R-22**] [**R-134a**] [**or**] [**any HFC**] <**Insert type**>. Classified as Safety Group A1 according to ASHRAE 34.
3. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
4. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
5. Pressure Relief Device:

    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

6. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
7. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.[**In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.**]

K. Evaporator:

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent liquid refrigerant carryover from entering compressor.
4. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
5. Tubes:

    a. Individually replaceable from either end and without damage to tube sheets and other tubes.
    b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.

c. Material: [**Copper**] [**Copper-nickel alloy**] [**Copper or copper-nickel alloy**] <**Insert material**>.
d. Nominal OD: [**Manufacturer's choice**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**3/4 or 1 inch (19 or 25 mm)**].
e. Minimum Wall Thickness: [**Manufacturer's choice**] [**0.025 inch (0.6 mm)**] [**0.028 inch (0.7 mm)**] [**0.035 inch (0.9 mm)**] <**Insert dimension**>.
f. External Finish: Manufacturer's standard.
g. Internal Finish: [**Enhanced**] [**Smooth**] [**Enhanced or smooth**].

6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Box:

a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
b. [**Standard**] [**Marine**] type for water box with piping connections. Standard type for water box without piping connections.
c. Provide water boxes [**and marine water-box covers**]with lifting lugs or eyebolts.
d. [**Hinged**] [**or**] [**davited**] water boxes.
e. [**Hinged**] [**or**] [**davited**] marine water-box covers.
f. Nozzle Pipe Connections: [**Welded, ASME B16.5, flat-face flange**] [**Welded, ASME B16.5, raised-face flange**] [**Grooved for mechanical-joint coupling**] [**Grooved with mechanical-joint coupling and flange adapter**].
g. Thermistor or RTD temperature sensor factory installed in each nozzle.
h. Fit each water box with [**3/4-inch (19-mm)**] [**1-inch (25-mm)**] [**3/4- or 1-inch (19- or 25-mm)**] <**Insert size**> drain connection at low point and vent connection at high point, each with threaded plug.

9. Additional Corrosion Protection:

a. Electrolytic corrosion-inhibitor anode.
b. Coat wetted surfaces with a corrosion-resistant finish.

L. Condenser:

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
5. Tubes:

a. Individually replaceable from either end and without damage to tube sheets and other tubes.

b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
c. Material: [**Copper**] [**Copper-nickel alloy**] [**Copper or copper-nickel alloy**] <**Insert material**>.
d. Nominal OD: [**Manufacturer's choice**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**3/4 or 1 inch (19 or 25 mm)**].
e. Minimum Wall Thickness: [**Manufacturer's choice**] [**0.025 inch (0.6 mm)**] [**0.028 inch (0.7 mm)**] [**0.035 inch (0.9 mm)**] <**Insert dimension**>.
f. External Finish: Manufacturer's standard.
g. Internal Finish: [**Enhanced**] [**Smooth**] [**Enhanced or smooth**].

6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Box:

a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
b. [**Standard**] [**Marine**] type for water box with piping connections. Standard type for water box without piping connections.
c. Provide water boxes [**and marine water-box covers**]with lifting lugs or eyebolts.
d. [**Hinged**] [**or**] [**davited**] water boxes.
e. [**Hinged**] [**or**] [**davited**] marine water-box covers.
f. Nozzle Pipe Connections: [**Welded, ASME B16.5, flat-face flange**] [**Welded, ASME B16.5, raised-face flange**] [**Grooved for mechanical-joint coupling**] [**Grooved with mechanical-joint coupling and flange adapter**].
g. Thermistor or RTD temperature sensor factory installed in each nozzle.
h. Fit each water box with [**3/4-inch (19-mm)**] [**1-inch (25-mm)**] [**3/4- or 1-inch (19- or 25-mm)**] <**Insert size**> drain connection at low point and vent connection at high point, each with threaded plug.

9. Additional Corrosion Protection:

a. Electrolytic corrosion-inhibitor anode.
b. Coat wetted surfaces with a corrosion-resistant finish.

M. Heat-Reclaim Condenser:

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Tubes:

a. Individually replaceable from either end and without damage to tube sheets and other tubes.

b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
c. Material: [**Copper**] [**Copper-nickel alloy**] [**Copper or copper-nickel alloy**] <**Insert material**>.
d. Nominal OD: [**Manufacturer's choice**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**3/4 or 1 inch (19 or 25 mm)**].
e. Minimum Wall Thickness: [**Manufacturer's choice**] [**0.025 inch (0.6 mm)**] [**0.028 inch (0.7 mm)**] [**0.035 inch (0.9 mm)**] <**Insert dimension**>.
f. External Finish: Manufacturer's standard.
g. Internal Finish: [**Enhanced**] [**Smooth**] [**Enhanced or smooth**].

5. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
7. Water Box:

a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
b. [**Standard**] [**Marine**] type for water box with piping connections. Standard type for water box without piping connections.
c. Provide water boxes [**and marine water-box covers**]with lifting lugs or eyebolts.
d. [**Hinged**] [**or**] [**davited**] water boxes.
e. [**Hinged**] [**or**] [**davited**] marine water-box covers.
f. Nozzle Pipe Connections: [**Welded, ASME B16.5, flat-face flange**] [**Welded, ASME B16.5, raised-face flange**] [**Grooved for mechanical-joint coupling**] [**Grooved with mechanical-joint coupling and flange adapter**].
g. Thermistor or RTD temperature sensor factory installed in each nozzle.
h. Fit each water box with [**3/4-inch (19-mm)**] [**1-inch (25-mm)**] [**3/4- or 1-inch (19- or 25-mm)**] <**Insert size**> drain connection at low point and vent connection at high point, each with threaded plug.

8. Additional Corrosion Protection:

a. Electrolytic corrosion-inhibitor anode.
b. Coat wetted surfaces with a corrosion-resistant finish.

N. Electrical Power:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**]. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.

a. Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls[**with disconnect switch or circuit breaker**].
b. NEMA- and ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
c. Control-circuit transformer with primary and secondary side fuses.

3. Terminal blocks with numbered [**and color-coded**]wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Factory-installed wiring outside of enclosures shall be in metal raceway except make connections to each motor and heater with not more than a 24-inch (610-mm) length of liquidtight conduit.
5. Factory install and wire capacitor bank for the purpose of power factor correction to [**0.95**] <**Insert value**> at all operating conditions.

    a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
    b. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
    c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within 1 minute after de-energizing.
    d. Provide a ground terminal and a terminal block or individual connectors for phase connection.

O. Motor Controller:

1. Enclosure: [**Factory installed, unit mounted**] [**Factory furnished, field mounted**], [**NEMA 250**] [**NEMA ICS 6**], [**Type 1**] [**Type 4**] [**Type 4X**] [**Type 12**] <**Insert type**>, with hinged full-front access door[**with lock and key or padlock and key**].
2. Control Circuit: Obtained from [**integral control power transformer**] <**Insert source of control power**> with a control power [**transformer**] [**source**] of enough capacity to operate connected control devices.
3. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
6. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
7. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.

    a. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
    b. Visual indication of motor and control status, including the following conditions:

        1) Controller on.
        2) Overload trip.
        3) Loss of phase.
        4) Starter fault.

8. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

a. Externally Operated[**, Door-Interlocked**] Disconnect: [**Fused disconnect switch**] [**Nonfused disconnect switch**] [**Circuit breaker**]. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.
b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
d. Control Relays: Time-delay relays.
e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
f. Number-of-Starts Counter: Numerical readout on face of enclosure.
g. Meters: Panel type, [**2-1/2 inches (64 mm)**] [**4-1/4 inches (108 mm)**] with [**90**] [**120**] [**270**]-degree scale and [**1**] [**2**] percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

1) Ammeter: Output current for each phase, with current sensors rated to suit application.
2) Voltmeter: Output voltage for each phase.
3) Frequency Meter: Output frequency.
4) Real-time clock with current time and date.
5) Total run time.
6) <**Insert features**>.

h. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1) Selectable, digital display of the following:

a) Phase Currents, Each Phase: Plus or minus 1 percent.
b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d) Three-Phase Real Power: Plus or minus 2 percent.
e) Three-Phase Reactive Power: Plus or minus 2 percent.
f) Power Factor: Plus or minus 2 percent.
g) Frequency: Plus or minus 0.5 percent.
h) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.

i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
j. Power Protection: Chiller shall shut down within six cycles of power interruption.

P. Variable Frequency Controller:

1. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
2. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
3. Enclosure: Unit mounted, NEMA 250, [**Type 1**] <**Insert type**>, with hinged full-front access door with lock and key.
4. Integral Disconnecting Means: [**Door-interlocked,**]NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] [**100,000**] <**Insert value**> A.
5. Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.
6. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
7. Operating Requirements:

    a. Input AC Voltage Tolerance: [**460-V ac, plus 10 percent or 506 V maximum**] <**Insert voltage and tolerance**>.
    b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
    c. Capable of driving full load, without derating, under the following conditions:

        1) Ambient Temperature: 0 to 40 deg C.
        2) Relative Humidity: Up to [**90**] [**95**] percent (noncondensing).
        3) Altitude: [**3300 feet (1005 m)**] [**6600 feet (2010 m)**].

    d. Minimum Efficiency: 96 percent at 60 Hz, full load.
    e. Minimum Displacement Primary-Side Power Factor: 98 percent.
    f. Overload Capability: 1.05 times the full-load current for 7 seconds.
    g. Starting Torque: As required by compressor-drive assembly.
    h. Speed Regulation: Plus or minus 1 percent.
    i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
    j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
    k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

8. Internal Adjustability Capabilities:

    a. Minimum Output Frequency: 6 Hz.
    b. Maximum Output Frequency: 60 Hz.
    c. Acceleration: 2 seconds to 60 seconds.
    d. Deceleration: Zero seconds to 60 seconds.
    e. Current Limit: 30 to a minimum of 100 percent of maximum rating.

9. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

    a. Overtemperature.
    b. Short circuit at controller output.

c. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
d. Open circuit at controller output.
e. Input undervoltage.
f. Input overvoltage.
g. Loss of input-phase.
h. Reverse phase.
i. AC line switching transients.
j. Instantaneous overload, line to line or line to ground.
k. Sustained overload exceeding 100 percent of controller rated current.
l. Starting a rotating motor.

10. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
11. Automatic Reset and Restart: Capable of [**three**] <**Insert number**> restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
12. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

a. Power on.
b. Run.
c. Overvoltage.
d. Line fault.
e. Overcurrent.
f. External fault.
g. Motor speed (percent).
h. Fault or alarm status (code).
i. Motor output voltage.
j. Input kilovolt amperes.
k. Total power factor.
l. Input kilowatts.
m. Input kilowatt-hours.
n. Three-phase input voltage.
o. Three-phase output voltage.
p. Three-phase input current.
q. Three-phase output current.
r. Output frequency (Hertz).
s. Elapsed operating time (hours).
t. Diagnostic and service parameters.

13. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
14. Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to [**5**] <**Insert number**> percent.

Q. Controls:

1. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

2. Enclosure: Unit mounted, NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**] <**Insert type**>, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

    a. Date and time.
    b. Operating or alarm status.
    c. Fault history with not less than last 10 faults displayed.
    d. Set points of controllable parameters.
    e. Trend data.
    f. Operating hours.
    g. Number of chiller starts.
    h. Outdoor-air temperature or space temperature if required for chilled-water reset.
    i. Temperature and pressure of operating set points.
    j. Entering- and leaving-fluid temperatures of evaporator and condenser.
    k. Difference in fluid temperatures of evaporator and condenser.
    l. Fluid flow of evaporator and condenser.
    m. Fluid pressure drop of evaporator and condenser.
    n. Refrigerant pressures in evaporator and condenser.
    o. Refrigerant saturation temperature in evaporator and condenser.
    p. Pump status.
    q. Antirecycling timer status.
    r. Percent of maximum motor amperage.
    s. Current-limit set point.
    t. Compressor bearing temperature.
    u. Motor bearing temperature.
    v. Motor winding temperature.
    w. Oil temperature.
    x. Oil discharge pressure.
    y. Phase current.
    z. Percent of motor rated load amperes.
    aa. Phase voltage.
    bb. Demand power (kilowatts).
    cc. Energy use (kilowatt-hours).
    dd. Power factor.
    ee. <**Insert items**>.

4. Control Functions:

    a. Manual or automatic startup and shutdown time schedule.
    b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on [**return-water**] [**outdoor-air**] [**space**] temperature.
    c. Current limit and demand limit.
    d. Condenser-fluid temperature.
    e. External chiller emergency stop.
    f. Antirecycling timer.
    g. Variable evaporator flow.
    h. Thermal storage.

i. Heat reclaim.
j. <**Insert control functions**>.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

a. Low evaporator pressure or temperature; high condenser pressure.
b. Low evaporator fluid temperature.
c. Low oil differential pressure.
d. High or low oil pressure.
e. High oil temperature.
f. High compressor-discharge temperature.
g. Loss of condenser-fluid flow.
h. Loss of evaporator-fluid flow.
i. Motor overcurrent.
j. Motor overvoltage.
k. Motor undervoltage.
l. Motor phase reversal.
m. Motor phase failure.
n. Sensor- or detection-circuit fault.
o. Processor communication loss.
p. Motor controller fault.
q. Extended compressor surge.
r. <**Insert manually reset safety controls**>.

6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Communication Port: RS-232 port or equivalent connection capable of connecting a printer[**and a notebook computer**].
10. Interface with the DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

a. Hardwired Points:

1) Monitoring: On-off status, [**common trouble alarm**] [**electrical power demand (kilowatts)**] [**electrical power consumption (kilowatt-hours)**] [**power factor**] <**Insert monitoring point**>.
2) Control: On-off operation, [**chilled-water, discharge temperature set-point adjustment**] [**electrical power demand limit**] <**Insert control point**>.

b. [**ASHRAE 135 (BACnet)**] [**LonTalk**] [**Modbus**] [**Industry-accepted, open-protocol**] <**Insert type of interface**> communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and

monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

R. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
2. Thickness: [**3/4 inch (19 mm)**] [**1-1/2 inches (38 mm)**] <**Insert thickness**>.
3. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

    a. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
    b. Seal seams and joints to provide a vapor barrier.
    c. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

S. Finish:

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

    a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
    b. Provide at least two coats of [**alkyd-modified, vinyl enamel**] [**epoxy**] [**polyurethane**] finish with a total dry film thickness of at least 4 mils (0.10 mm).
    c. Paint surfaces that are to be insulated before applying the insulation.
    d. Paint installed insulation to match adjacent uninsulated surfaces.
    e. Color of finish coat to be [**manufacturer's standard**] [**custom color selected by Architect**] <**Insert color description**>.

2. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

T. Accessories:

1. Flow Switches:

    a. If required and not factory installed, chiller manufacturer shall furnish a switch for each [**condenser**] [**evaporator and condenser**] and verify field-mounting location before installation.
    b. Paddle Flow Switches:

        1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
3) Pressure rating equal to pressure rating of heat exchanger.
4) Construct body and wetted parts of Type 316 stainless steel.
5) House switch in a NEMA 250, [**Type 4**] <**Insert type**> enclosure constructed of die-cast aluminum.
6) Vane length to suit installation.

c. Pressure Differential Switches:

1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
3) Set Point: Screw type, field adjustable.
4) Electrical Connections: Internally mounted screw-type terminal blocks.
5) Switch Enclosure: NEMA 250, [**Type 4**] <**Insert type**>.
6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

2. Vibration Isolation:

a. Chiller manufacturer shall furnish vibration isolation for each chiller.
b. Neoprene Pad:

1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
2) Fabricate pads from 40- to 50-durometer neoprene.
3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

c. Spring Isolator:

1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed such that the Kx/Ky ratio shall be 1.0 or more for stability.
2) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
3) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.
4) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.

5) Isolators shall be selected for a nominal [**1-inch (25-mm)**] [**2-inch (50-mm)**] <**Insert dimension**> deflection.

3. Sound Barrier:

a. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
b. Provide for repeated installation and removal without use of tape or calk.
c. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
d. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
e. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
f. Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.
g. Permanently label each section of cover to indicate its location, description, size, and number sequence.
h. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

4. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

U. Capacities and Characteristics:

1. Capacity: <**Insert tons (kW)**>.
2. Full-Load Efficiency (COP): <**Insert value**>.
3. Full-Load Efficiency (EER): <**Insert value**>.
4. Full-Load Efficiency (Power Input/Cooling Output): <**Insert kW/ton (kW/kW)**>.
5. Part-Load Efficiency (IPLV): <**Insert value**>.
6. Part-Load Efficiency (NPLV): <**Insert value**>.
7. Evaporator:

a. Pressure Rating: <**Insert psig (kPa)**>.
b. Number of Passes: [**One**] [**Two**] [**Three**].
c. Fluid Type: [**Water**] <**Insert fluid type**>.
d. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
e. Minimum Fluid Flow Rate: <**Insert gpm (L/s)**>.
f. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
g. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
h. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
i. Fluid Velocity: <**Insert fps (m/s)**>.
j. Fouling Factor: [**0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)**] [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] <**Insert value**>.

8. Condenser:

   a. Pressure Rating: <**Insert psig (kPa)**>.
   b. Number of Passes: [**One**] [**Two**] [**Three**].
   c. Fluid Type: [**Water**] <**Insert fluid type**>.
   d. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
   e. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
   f. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
   g. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
   h. Fluid Velocity: <**Insert fps (m/s)**>.
   i. Fouling Factor: [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] [**0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)**] <**Insert value**>.

9. Heat-Reclaim Condenser:

   a. Pressure Rating: <**Insert psig (kPa)**>.
   b. Number of Passes: [**One**] [**Two**] [**Three**].
   c. Fluid Type: [**Water**] <**Insert fluid type**>.
   d. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
   e. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
   f. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
   g. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
   h. Fluid Velocity: <**Insert fps (m/s)**>.
   i. Fouling Factor: [**0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)**] [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] <**Insert value**>.

10. Compressor:

    a. Rated Load Amperes: <**Insert value**>.
    b. Locked-Rotor Amperes: <**Insert value**>.

11. Chiller Electrical Requirements:

    a. Power Input: <**Insert kilowatts**>.
    b. Power Factor: [**0.90**] [**0.95**] <**Insert value**>.
    c. Minimum Circuit Ampacity: <**Insert value**>.
    d. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    e. Volts: [**208**] [**240**] [**480**] [**600**] [**2300**] [**4160**] <**Insert value**>.
    f. Phase: Three.
    g. Hertz: 60.

12. Noise Rating: [**85**] <**Insert dBA**> sound power level when measured according to ARI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.2 PACKAGED, WATER-COOLED, MULTIPLE-COMPRESSOR CHILLERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: Factory-assembled and [**run**]-tested chiller with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.

1. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.

C. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

D. Compressors:

1. Description: Positive displacement, hermetically sealed.
2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
3. Rotors: Manufacturer's standard one- or two-rotor design.

E. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

F. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to [**20**] [**15**] [**10**] [**5**] [**zero**] <**Insert number**> percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: [**Constant-design entering condenser-fluid temperature**] [**Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction**] <**Insert conditions**>.

G. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Factory-installed and pressure-tested piping with isolation valves and accessories.
4. Oil compatible with refrigerant and chiller components.
5. Positive visual indication of oil level.

H. Vibration Control:

1. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

a. Overspeed Test: 25 percent above design operating speed.

2. Isolation: Mount individual compressors on vibration isolators.

I. Sound Control: Sound-reduction package shall consist of removable acoustic enclosures around the compressors and drive assemblies that are designed to reduce sound levels without affecting performance.

J. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, induction type with inherent thermal-overload protection on each phase.

K. Refrigerant Circuits:

1. Refrigerant: Type as indicated on Drawings.
2. Refrigerant Type: [**R-22**] [**R-134a**] [**or**] [**any HFC**] <**Insert type**>. Classified as Safety Group A1 according to ASHRAE 34.
3. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
4. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor[**suction**] and discharge shutoff valves, a liquid-line shutoff valve, a[**replaceable-core**] filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
5. Pressure Relief Device:

    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

6. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid-line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.

L. Evaporator:

1. Description: Shell-and-tube design.

    a. Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.

2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads with multipass baffles, and located at each end of the tube bundle.
5. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

M. Condenser:

1. Shell and tube, or without integral condenser; as indicated.
2. Shell and Tube:

    a. Description: Shell-and-tube design with refrigerant flowing through shell, and fluid flowing through tubes within shell.
    b. Provides positive subcooling of liquid refrigerant.
    c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    d. Shell Material: Carbon steel.
    e. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
    f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
    g. Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.

3. Provide chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Section 236313 "Air-Cooled Refrigerant Condensers."

N. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a [**multipoint**] [**single-point**], field-power connection to chiller.
2. House in a unit-mounted, NEMA 250, [**Type 1**] <**Insert type**> enclosure with hinged access door[**with lock and key or padlock and key**].
3. Wiring shall be numbered[**and color-coded**] to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field-power interface shall be to [**wire lugs**] [**NEMA KS 1, heavy-duty, nonfused disconnect switch**] [**NEMA AB 1, instantaneous-trip circuit breaker with lockable handle**].

    a. Disconnect means shall be interlocked with door operation.
    b. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] [**100,000**] <**Insert value**> A.

6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

    a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

7. Provide each motor with overcurrent protection.

8. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
10. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
11. Control Relays: Auxiliary and adjustable time-delay relays.
12. For chiller electrical power supply, indicate the following:

    a. Current and phase to phase for all three phases.
    b. Voltage, phase to phase, and phase to neutral for all three phases.
    c. Three-phase real power (kilowatts).
    d. Three-phase reactive power (kilovolt amperes reactive).
    e. Power factor.
    f. Running log of total power versus time (kilowatt-hours).
    g. Fault log, with time and date of each.
    h. <**Insert features**>.

O. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing[**, or solid state**].
2. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed or open transition[**, or solid state**].

P. Controls:

1. Standalone and microprocessor based.
2. Enclosure: Share enclosure with electrical-power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

    a. Date and time.
    b. Operating or alarm status.
    c. Fault history with not less than last 10 faults displayed.
    d. Set points of controllable parameters.
    e. Trend data.
    f. Operating hours.
    g. Number of chiller starts.
    h. Outdoor-air temperature or space temperature if required for chilled-water reset.
    i. Temperature and pressure of operating set points.
    j. Entering- and leaving-fluid temperatures of evaporator and condenser.
    k. Difference in fluid temperatures of evaporator and condenser.
    l. Refrigerant pressures in evaporator and condenser.
    m. Refrigerant saturation temperature in evaporator and condenser.
    n. No cooling load condition.
    o. Elapsed time meter (compressor run status).
    p. Pump status.
    q. Antirecycling timer status.
    r. Percent of maximum motor amperage.
    s. Current-limit set point.

t. Number of compressor starts.
u. Compressor refrigerant suction and discharge temperature.
v. Oil temperature.
w. Oil discharge pressure.
x. Phase current.
y. Percent of motor rated load amperes.
z. Phase voltage.
aa. <**Insert items**>.

4. Control Functions:

a. Manual or automatic startup and shutdown time schedule.
b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on [**return-water**] [**outdoor-air**] [**space**] temperature.
c. Current limit and demand limit.
d. Condenser-fluid temperature.
e. External chiller emergency stop.
f. Antirecycling timer.
g. Automatic lead-lag switching.
h. Variable evaporator flow.
i. Thermal storage.
j. <**Insert control functions**>.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

a. Low evaporator pressure, or high condenser pressure.
b. Low chilled-water temperature.
c. Refrigerant high pressure.
d. High or low oil pressure.
e. High oil temperature.
f. Loss of chilled-water flow.
g. Loss of condenser-fluid flow.
h. Control device failure.
i. <**Insert manually reset safety controls**>.

6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

a. Hardwired Points:

1) Monitoring: On-off status, [**common trouble alarm**] [**electrical power demand (kilowatts)**] [**electrical power consumption (kilowatt-hours)**] <**Insert monitoring point**>.
2) Control: On-off operation, [**chilled-water, discharge temperature set-point adjustment**] [**electrical power demand limit**] <**Insert control point**>.

b. [**ASHRAE 135 (BACnet)**] [**LonTalk**] [**Modbus**] [**Industry-accepted, open-protocol**] <**Insert type of interface**> communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

Q. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
2. Thickness: [**3/4 inch (19 mm)**] <**Insert thickness**>.
3. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

a. Before insulating steel surfaces, prepare surfaces for paint, prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
b. Seal seams and joints to provide a vapor barrier.
c. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

R. Finish:

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

a. Provide at least one coat of primer.
b. Provide finish coat of [**alkyd-modified, vinyl enamel**] <**Insert type**>.
c. Paint surfaces that are to be insulated before applying the insulation.
d. Paint installed insulation to match adjacent uninsulated surfaces.

S. Accessories:

1. Factory-furnished, chilled-[**and condenser-**]water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
3. Factory-furnished [**neoprene**] [**or**] [**spring**] isolators for field installation.
4. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine

maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

T. Capacities and Characteristics:

1. Capacity: <**Insert tons (kW)**>.
2. Full-Load Efficiency (COP): <**Insert value**>.
3. Full-Load Efficiency (EER): <**Insert value**>.
4. Full-Load Efficiency (Power Input/Cooling Output): <**Insert kW/ton (kW/kW)**>.
5. Part-Load Efficiency (IPLV): <**Insert value**>.
6. Part-Load Efficiency (NPLV): <**Insert value**>.
7. Evaporator:

    a. Pressure Rating: <**Insert psig (kPa)**>.
    b. Number of Passes: [**One**] [**Two**] [**Three**].
    c. Fluid Type: [**Water**] <**Insert fluid type**>.
    d. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
    e. Minimum Fluid Flow Rate: <**Insert gpm (L/s)**>.
    f. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    g. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
    h. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
    i. Fluid Velocity: <**Insert fps (m/s)**>.
    j. Fouling Factor: [**0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)**] [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] <**Insert value**>.

8. Condenser:

    a. Pressure Rating: <**Insert psig (kPa)**>.
    b. Fluid Type: [**Water**] <**Insert fluid type**>.
    c. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
    d. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    e. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
    f. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
    g. Fluid Velocity: <**Insert fps (m/s)**>.
    h. Fouling Factor: [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] [**0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)**] <**Insert value**>.

9. Number of Refrigerant Circuits: [**One**] [**Two**].
10. Compressors:

    a. Number of Compressors: <**Insert number**>.
    b. Rated Load Amperes: <**Insert value**>.
    c. Locked-Rotor Amperes: <**Insert value**>.

11. Control Electrical Requirements:

    a. Power Connection: [**Fed through integral transformer**] [**Separate field-power connection**].
    b. Power Input: <**Insert kilowatts**>.

c. Minimum Circuit Ampacity: <**Insert value**>.
d. Maximum Overcurrent Protection Device: <**Insert amperage**>.
e. Volts: [**120**] <**Insert value**>-V ac.
f. Phase: [**Single**] [**Three**].
g. Hertz: 60.

12. Chiller Electrical Requirements:

a. Power Input: <**Insert kilowatts**>.
b. Power Factor: <**Insert value**>.
c. Minimum Circuit Ampacity: <**Insert value**>.
d. Maximum Overcurrent Protection Device: <**Insert amperage**>.
e. Volts: [**208**] [**240**] [**480**] [**600**] <**Insert value**>.
f. Phase: Three.
g. Hertz: 60.

13. Noise Rating: <**Insert dBA**> sound power level when measured according to ARI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.3 PACKAGED, AIR-COOLED CHILLERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

C. Fabricate base, frame, and attachment to chiller components strong enough to resist chiller movement during a seismic event when chiller base is anchored to field support structure.

D. Cabinet:

1. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
3. Casing: Galvanized steel.
4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a [**500**] [**1000**] <**Insert number**>-hour salt-spray test according to ASTM B 117.
5. Sound-reduction package designed to reduce sound level without affecting performance and consisting of the following:

a. Acoustic enclosure around compressors.
b. Reduced-speed fans with acoustic treatment.

6. Security Package: Provide removable [**grilles**] [**louvered panels**] with fasteners for additional protection of compressors, evaporator, and condenser coils without inhibiting service access. Finish to match cabinet.

E. Compressors:

1. Description: Positive displacement, hermetically sealed.
2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
3. Rotors: Manufacturer's standard one- or two-rotor design.
4. Each compressor provided with[**suction and**] discharge shutoff valves, crankcase oil heater, and suction strainer.

F. Service: Easily accessible for inspection and service.

G. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to [**20**] [**15**] [**10**] [**5**] [**zero**] <**Insert number**> percent of design capacity.
3. Condenser-Air Unloading Requirements over Operating Range: [**Constant-design entering condenser-air temperature**] [**Drop-in entering condenser-air temperature of 5 deg F (3 deg C) drop for each 10 percent in capacity reduction**] <**Insert conditions**>.
4. For units equipped with a variable frequency controller, capacity control shall be both "valveless" and "stepless," requiring no slide valve or capacity-control valve(s) to operate at reduced capacity.

H. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Factory-installed and pressure-tested piping with isolation valves and accessories.
4. Oil compatible with refrigerant and chiller components.
5. Positive visual indication of oil level.

I. Vibration Control:

1. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.

    a. Overspeed Test: 25 percent above design operating speed.

2. Isolation: Mount individual compressors on vibration isolators.

J. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, induction type with inherent thermal-overload protection on each phase.

K. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing[**, or solid state**].
2. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition[**, or solid state**].
3. Variable Frequency Controller:

    a. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
    b. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
    c. Enclosure: Unit mounted, NEMA 250, [**Type 3R**] <**Insert type**>, with hinged full-front access door with lock and key.
    d. Integral Disconnecting Means: [**Door-interlocked,**]NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] [**100,000**] <**Insert value**> A.
    e. Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.
    f. Motor current at start shall not exceed the rated load amperes, providing no electrical inrush.

L. Refrigerant Circuits:

1. Refrigerant: Type as indicated on Drawings.
2. Refrigerant Type: [**R-22**] [**R-134a**] [**R-407c**] [**or**] [**any HFC**] <**Insert type**>. Classified as Safety Group A1 according to ASHRAE 34.
3. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
4. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor[**suction**] and discharge shutoff valves, a liquid-line shutoff valve, a [**replaceable-core**]filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
5. Pressure Relief Device:

    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

M. Evaporator:

1. Description: Shell-and-tube design.

    a. Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.

2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.

5. Fluid Nozzles: Terminated with [**mechanical-coupling**] [**flanged**] end connections for connection to field piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
7. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
8. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.

N. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).

    a. Construct coil casing of [**galvanized**] [**or**] [**stainless**] steel.
    b. Construct coils of copper tubes mechanically bonded to [**aluminum**] [**aluminum with precoated epoxy-phenolic**] [**copper**] fins.
    c. Coat coils with a baked-epoxy, corrosion-resistant coating after fabrication.
    d. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
3. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
4. Fan Guards: Steel safety guards with corrosion-resistant coating.

O. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a [**multipoint**] [**single-point**], field-power connection to chiller.
2. House in a unit-mounted, NEMA 250, [**Type 3R**] <**Insert type**> enclosure with hinged access door[**with lock and key or padlock and key**].
3. Wiring shall be numbered[**and color-coded**] to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field-power interface shall be to [**wire lugs**] [**NEMA KS 1, heavy-duty, nonfused disconnect switch**] [**NEMA AB 1, instantaneous-trip circuit breaker with lockable handle**].

    a. Disconnect means shall be interlocked with door operation.
    b. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] [**100,000**] <**Insert value**> A.

6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

    a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
10. Provide power factor correction capacitors to correct power factor to [**0.90**] [**0.95**] <**Insert value**> at full load.
11. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

    a. Power unit-mounted controls where indicated.
    b. Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.

12. Control Relays: Auxiliary and adjustable time-delay relays.
13. For chiller electrical power supply, indicate the following:

    a. Current and phase to phase for all three phases.
    b. Voltage, phase to phase, and phase to neutral for all three phases.
    c. Three-phase real power (kilowatts).
    d. Three-phase reactive power (kilovolt amperes reactive).
    e. Power factor.
    f. Running log of total power versus time (kilowatt-hours).
    g. Fault log, with time and date of each.
    h. <**Insert features**>.

P. Controls:

1. Standalone and microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure[**for remote mounting in the field**].
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

    a. Date and time.
    b. Operating or alarm status.
    c. Operating hours.
    d. Outdoor-air temperature if required for chilled-water reset.
    e. Temperature and pressure of operating set points.
    f. Entering and leaving temperatures of chilled water.
    g. Refrigerant pressures in evaporator and condenser.
    h. Saturation temperature in evaporator and condenser.
    i. No cooling load condition.
    j. Elapsed time meter (compressor run status).
    k. Pump status.
    l. Antirecycling timer status.
    m. Percent of maximum motor amperage.
    n. Current-limit set point.
    o. Number of compressor starts.

p. <**Insert items**>.

4. Control Functions:

   a. Manual or automatic startup and shutdown time schedule.
   b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on [**return-water**] [**outdoor-air**] [**space**] temperature.
   c. Current limit and demand limit.
   d. External chiller emergency stop.
   e. Antirecycling timer.
   f. Automatic lead-lag switching.
   g. Variable evaporator flow.
   h. Thermal storage.
   i. <**Insert control functions**>.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

   a. Low evaporator pressure or high condenser pressure.
   b. Low chilled-water temperature.
   c. Refrigerant high pressure.
   d. High or low oil pressure.
   e. High oil temperature.
   f. Loss of chilled-water flow.
   g. Control device failure.
   h. <**Insert manually reset safety controls**>.

6. Trending: Capability to trend analog data of up to [**five**] <**Insert number**> parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

   a. Hardwired Points:

      1) Monitoring: On-off status, [**common trouble alarm**] [**electrical power demand (kilowatts)**] [**electrical power consumption (kilowatt-hours)**] <**Insert monitoring point**>.
      2) Control: On-off operation, [**chilled-water, discharge temperature set-point adjustment**] [**electrical power demand limit**] <**Insert control point**>.

   b. [**ASHRAE 135 (BACnet)**] [**LonTalk**] [**Modbus**] [**Industry-accepted, open-protocol**] <**Insert type of interface**> communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely

control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

Q. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
2. Thickness: [**3/4 inch (19 mm)**] [**1-1/2 inches (38 mm)**] <**Insert thickness**>.
3. Factory-applied insulation over cold surfaces of chiller components.

    a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.

4. Apply protective coating to exposed surfaces of insulation to protect insulation from weather.

R. Accessories:

1. Factory-furnished, chilled-water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
3. Factory-furnished [**neoprene**] [**or**] [**spring**] isolators for field installation.
4. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

S. Capacities and Characteristics:

1. Capacity: <**Insert tons (kW)**>.
2. Full-Load Efficiency (COP): <**Insert value**>.
3. Full-Load Efficiency (EER): <**Insert value**>.
4. Full-Load Efficiency (Power Input/Cooling Output): <**Insert kW/ton (kW/kW)**>.
5. Part-Load Efficiency (IPLV): <**Insert value**>.
6. Part-Load Efficiency (NPLV): <**Insert value**>.
7. Low Ambient Operation: Chiller designed for operation to [**0 deg F (minus 18 deg C)**] <**Insert temperature**>.
8. High Ambient Operation: Chiller designed for operation to [**115 deg F (46 deg C)**] <**Insert temperature**>.
9. Evaporator:

    a. Configuration: [**Integral to chiller**] [**Shipped loose for field installation**].
    b. Pressure Rating: [**150 psig (1034 kPa)**] [**300 psig (2068 kPa)**] <**Insert value**>.
    c. Fluid Type: [**Water**] <**Insert fluid type**>.
    d. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
    e. Minimum Fluid Flow Rate: <**Insert gpm (L/s)**>.
    f. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
    g. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
    h. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.

i. Fluid Velocity: <**Insert fps (m/s)**>.
j. Fouling Factor: [**0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)**] [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] <**Insert value**>.

10. Condenser Entering-Air Temperature: <**Insert deg F (deg C)**>.
11. Condenser Fan External Static Pressure: <**Insert wg (Pa)**>.
12. Site Altitude: <**Insert feet (m)**>.
13. Number of Refrigerant Circuits: [**Two**] [**Each compressor on an independent circuit**] <**Insert requirement**>.
14. Compressor:

    a. Number of Compressors: <**Insert number**>.
    b. Rated Load Amperes: <**Insert value**>.
    c. Locked-Rotor Amperes: <**Insert value**>.

15. Control Electrical Requirements:

    a. Power Connection: [**Fed through integral transformer**] [**Separate field-power connection**].
    b. Power Input: <**Insert kilowatts**>.
    c. Minimum Circuit Ampacity: <**Insert value**>.
    d. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    e. Volts: [**120**] <**Insert value**>-V ac.
    f. Phase: Single.
    g. Hertz: 60.

16. Chiller Electrical Requirements:

    a. Power Input: <**Insert kilowatts**>.
    b. Power Factor: <**Insert value**>.
    c. Minimum Circuit Ampacity: <**Insert value**>.
    d. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    e. Volts: [**208**] [**240**] [**480**] [**600**] <**Insert value**>.
    f. Phase: Three.
    g. Hertz: 60.

17. Noise Rating: <**Insert dBA**> sound power level when measured according to ARI 370. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.4 PACKAGED REFRIGERANT RECOVERY UNITS

A. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.

2.5 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

A. Furnish for field installation a brush-cleaning system on each chiller [**condenser**] <**Insert heat exchanger**> for tube cleaning and improved heat transfer.

B. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.

C. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.

D. Components:

1. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
2. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
3. Four-Way Valve:

    a. Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
    b. Configure valve with parallel flow connections to minimize field installation piping.
    c. Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
    d. Pipe connections shall be flanged.
    e. Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
    f. Hydrostatically test to 1.5 times the design working pressure.
    g. Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
    h. Provide valve with valve-mounted indicating/warning light, which shall light before valve begins rotation.
    i. Valve Actuator: Mount electric actuator to operate valve.
    j. Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
    k. Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.

4. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:

    a. NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**] enclosure.
    b. Timer to automatically initiate the cleaning cycle over a 24-hour period.
    c. Manual override of preset cleaning cycle.

d. Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
e. For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
f. Flow switch bypass.
g. Unloading signal to chiller.

2.6 SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

B. Factory run test each air-cooled chiller with water flowing through evaporator.

C. Factory performance test water-cooled chillers, before shipping, according to ARI 506/110.

1. Test the following conditions:

a. Design conditions indicated.
b. Reduction in capacity from design to minimum load in steps of [**10**] [**25**] [**33**] <**Insert number**> with condenser fluid at design conditions.
c. Reduction in capacity from design to minimum load in steps of [**10**] [**25**] [**33**] <**Insert number**> with varying entering condenser-fluid temperature from design to minimum conditions in [**5 deg F (3 deg C)**] <**Insert temperature**> increments.
d. At [**one**] [**two**] [**three**] [**four**] [**five**] [**10**] <**Insert number**> point(s) of varying part-load performance to be selected by Owner at time of test.

2. Allow [**Owner**] <**Insert entity**> access to place where chillers are being tested. Notify Architect [**14**] <**Insert number**> days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

D. Factory performance test air-cooled chillers, before shipping, according to ARI 506/110.

1. Test the following conditions:

a. Design conditions indicated.
b. Reduction in capacity from design to minimum load in steps of [**10**] [**25**] [**33**] <**Insert number**> with condenser air at design conditions.
c. At [**one**] [**two**] [**three**] [**four**] [**five**] <**Insert number**> point(s) of varying part-load performance to be selected by Owner at time of test.

2. Allow [**Owner**] <**Insert entity**> access to place where chillers are being tested. Notify Architect [**14**] <**Insert number**> days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

E. Factory sound test [**water-cooled chillers, before shipping, according to ARI 575**] [**air-cooled chillers, before shipping, according to ARI 370**].

1. Test the following conditions:

a. Design conditions indicated.
b. Chiller operating at calculated worst-case sound condition.
c. At [**one**] [**two**] [**three**] [**four**] [**five**] <**Insert number**> point(s) of varying part-load performance to be selected by Owner at time of test.

2. Allow [**Owner**] <**Insert entity**> access to place where chillers are being tested. Notify Architect [**14**] <**Insert number**> days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

F. Factory test and inspect evaporator[**and condenser**] [**, condenser, and heat-reclaim condenser**] according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

G. For chillers located indoors, rate sound power level according to ARI 575.

H. For chillers located outdoors, rate sound power level according to ARI 370.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CHILLER INSTALLATION

A. Install chillers on support structure indicated.

B. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Charge chiller with refrigerant and fill with oil if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

3.3 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM INSTALLATION

A. Install brush-cleaning system control panel adjacent to chiller control panel.

B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.

C. Provide field electric power, as required, to each system control panel and electric actuated valve.

D. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.

E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.

F. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," [**and**] [**Section 232300 "Refrigerant Piping"**]. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, [**strainer,**] [**flexible connector,**] thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve,[**flexible connector,**] flow switch, thermometer, plugged tee with shutoff valve and pressure gage,[**flow meter,**] and drain connection with valve. Make connections to chiller with a [**flange**] [**or**] [**mechanical coupling**].

D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, [**strainer,**] [**flexible connector,**] thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve,[**flexible connector,**] flow switch, thermometer, plugged tee with shutoff valve and pressure gage,[**flow meter,**] and drain connection with valve. Make connections to chiller with a [**flange**] [**or**] [**mechanical coupling**].

E. Heat-Reclaim Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, [**strainer,**] [**flexible connector,**] thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve,[**flexible connector,**] flow switch, thermometer, plugged tee with shutoff valve and pressure gage,[**flow meter,**] and drain connection with valve. Make connections to chiller with a [**flange**] [**or**] [**mechanical coupling**].

F. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend [**vent piping**] [**separate vent piping for each chiller**] to the outdoors without valves or restrictions.

Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.

G. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator[**and condenser**] [**, condenser, and heat-reclaim condenser**].
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.[**Video record the training sessions.**]

END OF SECTION 236426