SECTION 236419 - RECIPROCATING 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, electric-motor-driven, reciprocating water chillers.
2. Packaged, air-cooled, electric-motor-driven, reciprocating water chillers.
3. Packaged refrigerant recovery units.

B. Related Sections:

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: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons 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 the ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Reciprocating water chillers shall withstand the effects of earthquake motions determined according to [**SEI/ASCE 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**]."

1.5 ACTION SUBMITTALS

A. Product Data: 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 water chiller.
5. Oil capacity of water chiller.
6. Fluid capacity of evaporator.
7. Fluid capacity of condenser.
8. Characteristics of safety relief valves.
9. Minimum entering condenser-water temperature.
10. Performance at varying capacity with constant-design entering condenser-water temperature. Repeat performance at varying capacity for different entering condenser-water temperatures from design to minimum in [**5 deg F (3 deg C)**] <**Insert deg F (deg C)**> increments.
11. Minimum entering condenser-air temperature.
12. Performance at varying capacity with constant-design entering condenser-air temperature. Repeat performance at varying capacity for different entering condenser-air temperatures from design to minimum in [**10 deg F (6 deg C)**] <**Insert deg F (deg C)**> increments.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distributions.
3. Required clearances for maintenance and operation.
4. Sizes and locations of piping and wiring connections.
5. 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 water 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 test reports.

E. Startup service reports.

F. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

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

1.8 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 590 certification program.

B. ARI Rating: Rate water chiller performance according to requirements in ARI 506/110, "Water Chilling Packages Using the Vapor Compression Cycle."

C. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

F. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

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 water chillers that fail in materials or workmanship within specified warranty period.

1. Compressor Warranty Period: [**Five**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED WATER-COOLED WATER CHILLERS

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

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

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

D. Compressors:

1. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
3. Operating Speed: 1750 rpm for 60-Hz applications.
4. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling[**of multiple compressors**][**, plus hot-gas bypass**]. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.

5. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
6. Vibration Isolation: Mount individual compressors on either neoprene or spring isolators.
7. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.

E. Compressor Motors:

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

F. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
2. Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.

G. Refrigeration:

1. Refrigerant: R-22. Classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include [**a thermal**] [**an 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.
4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

H. Evaporator:

1. Brazed-plate or shell-and-tube design, as indicated.
2. Shell and Tube:

    a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
    b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    c. Shell Material: Carbon steel.
    d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
    e. Shell Nozzles: Fluid nozzles located along the side of the shell and 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.

3. Brazed Plate:

    a. Direct-expansion, single-pass, brazed-plate design.

b. Type 316 stainless-steel construction.
c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

I. Condenser:

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

a. Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
b. Provides positive subcooling of liquid refrigerant.
c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
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. Brazed Plate:

a. Single-pass, brazed-plate design provides positive subcooling of liquid refrigerant.
b. Type 316 stainless-steel construction.
c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
e. Provide each condenser with a liquid-line shutoff valve.

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

J. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water 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**].

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 KS 1, heavy-duty, nonfusible switch.
    c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
9. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
10. Controls 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. Indicate the following for water chiller electrical power supply:

    a. Current, 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**>.

K. Controls:

1. Stand-alone, microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

    a. Date and time.
    b. Operating or alarm status.
    c. Operating hours.
    d. Outside-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. Entering and leaving temperatures of condenser water.
    h. Refrigerant pressures in evaporator and condenser.
    i. Saturation temperature in evaporator and condenser.
    j. No cooling load condition.
    k. Elapsed time meter (compressor run status).
    l. Pump status.
    m. Antirecycling timer status.
    n. Percent of maximum motor amperage.
    o. Current-limit set point.

p. Number of compressor starts.
q. <**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 limit. Chilled-water leaving temperature shall be reset based on [**return-water**] [**outside-air**] [**space**] temperature.
c. Current limit and demand limit.
d. Condenser-water temperature.
e. External water chiller emergency stop.
f. Antirecycling timer.
g. Automatic lead-lag switching.
h. <**Insert functions**>.

5. Manual-Reset Safety Controls: The following conditions shall shut down water 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-water flow.
h. Control device failure.
i. <**Insert items**>.

6. Interface with DDC System for HVAC: Factory-installed hardware and software to enable DDC system for HVAC to monitor, control, and display water 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**] [**Industry-accepted open-protocol**] <**Insert type of interface**> communication interface with DDC system for HVAC shall enable DDC system for HVAC operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

L. 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. Factory-applied insulation over cold surfaces of water 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.

M. Accessories:

1. Factory-furnished, chilled-[**and condenser-**]water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves.
3. Factory-furnished spring isolators for field installation.

N. Capacities and Characteristics:

1. Capacity: <**Insert tons (kW)**>.
2. Full-Load Efficiency:

    a. COP: <**Insert number**>.
    b. EER: <**Insert number**>.
    c. Power Input/Cooling Output, kW/ton (kW/kW): <**Insert value**>.

3. Part-Load Efficiency:

    a. IPLV: <**Insert number**>.
    b. NPLV: <**Insert number**>.

4. Evaporator Type: [**Brazed plate**] [**Shell and tube**].
5. Evaporator Pressure Rating: <**Insert psig (kPa)**>.
6. Evaporator Fluid Type: [**Water**] <**Insert fluid type**>.
7. Design Evaporator Fluid Flow Rate: <**Insert gpm (L/s)**>.
8. Minimum Evaporator Fluid Flow Rate: <**Insert gpm (L/s)**>.
9. Evaporator Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
10. Evaporator Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
11. Evaporator Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
12. Evaporator 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 factor**>.
13. Condenser Type: [**Brazed plate**] [**Shell and tube**] [**Chiller without integral condenser**].
14. Condenser Pressure Rating: <**Insert psig (kPa)**>.
15. Condenser Fluid Type: [**Water**] <**Insert fluid type**>.
16. Condenser Fluid Flow Rate: <**Insert gpm (L/s)**>.
17. Condenser Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
18. Condenser Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
19. Condenser Fluid Pressure Drop: <**Insert feet of head (kPa)**>.

20. Condenser 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 factor**>.
21. Number of Refrigeration Circuits: [**One**] [**Two**].
22. Compressor Rated Load Amperes: <**Insert value**>.
23. Compressor Locked-Rotor Amperes: <**Insert value**>.
24. Controls Power Connection: [**Fed through integral transformer**] [**Separate field power connection**].

    a. Controls Power Input: <**Insert kilowatts**>.
    b. Controls Minimum Circuit Ampacity: <**Insert value**>.
    c. Controls Maximum Overcurrent Protection Device: <**Insert amperage**>.
    d. Controls Electrical Characteristics: [**120**] <**Insert value**>-V ac, [**single**] [**three**] phase, 60 Hz.

25. Chiller Power Input: <**Insert kilowatts**>.
26. Chiller Minimum Circuit Ampacity: <**Insert value**>.
27. Chiller Maximum Overcurrent Protection Device: <**Insert amperage**>.
28. Chiller Electrical Characteristics: [**208**] [**240**] [**480**] [**600**] <**Insert value**>-V ac, three phase, 60 Hz.
29. Noise Rating: <**Insert dBA**> at <**Insert distance in feet (m)**> when measured according to ARI 575.

2.2 PACKAGED AIR-COOLED WATER CHILLERS

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

B. Description: Factory-assembled and run-tested water 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 water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.

D. Cabinet:

1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit. Base shall be designed to limit deflection to L/200 and shall be a minimum of 4 inches ((100 mm))high.
2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components notdirectly supported from base.
3. Casing: Galvanized steel.
4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a [**500**] <**Insert hours**>-hour salt-spray test according to ASTM B 117.
5. Sound-reduction package consisting of the following:

    a. Acoustic enclosure around compressors.
    b. Reduced-speed fans with acoustic treatment.
    c. Designed to reduce sound level without affecting performance.

6. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

E. Compressors:

1. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
3. Operating Speed: 1750 rpm for 60-Hz applications.
4. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors[**, plus hot-gas bypass**]. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
5. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
6. Vibration Isolation: Mount individual compressors on spring isolators with an isolation efficiency of 95 percent.

F. Compressor Motors:

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

G. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
2. Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.

H. Refrigeration:

1. Refrigerant: R-22. Classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include [**a thermal**] [**an 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.
4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

I. Evaporator:

1. Description: Direct-expansion shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
5. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling 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.

J. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling circuit, leak tested at 150 psig (1034 kPa).

    a. Construct coils of copper tubes mechanically bonded to [**aluminum**] [**aluminum with precoated epoxy-phenolic**] [**copper**] fins.
    b. Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
    c. 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 air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
4. Fan Guards: Steel safety guards with corrosion-resistant coating.

K. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
2. House in a unit-mounted, NEMA 250, [**Type 3R**] [**Type 4**] <**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**].
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 KS 1, heavy-duty, nonfusible switch.
    c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Provide each motor with overcurrent protection.

8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
9. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
10. 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.

11. Control Relays: Auxiliary and adjustable time-delay relays.
12. Indicate the following for water chiller electrical power supply:

    a. Current, 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**>.

L. Controls:

1. Stand-alone, microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

    a. Date and time.
    b. Operating or alarm status.
    c. Operating hours.
    d. Outside-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 temperature, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on [**return-water**] [**outside-air**] [**space**] temperature.
c. Current limit and demand limit.
d. External water chiller emergency stop.
e. Antirecycling timer.
f. Automatic lead-lag switching.
g. <**Insert functions**>.

5. Manual-Reset Safety Controls: The following conditions shall shut down water 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 items**>.

6. Interface with DDC System for HVAC: Factory-installed hardware and software to enable DDC system for HVAC to monitor, control, and display water 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**] [**Industry-accepted open-protocol**] <**Insert type of interface**> communication interface with DDC system for HVAC shall enable DDC system for HVAC operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

M. 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. Factory-applied insulation over cold surfaces of water 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.

N. Accessories:

1. Factory-furnished, chilled-[**and condenser-**]water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves.
3. Factory-furnished spring isolators for field installation.

O. Capacities and Characteristics:

1. Capacity: <**Insert tons (kW)**>.
2. Full-Load Efficiency:

    a. COP: <**Insert number**>.
    b. EER: <**Insert number**>.
    c. Power Input/Cooling Output, kW/ton (kW/kW): <**Insert value**>.

3. Part-Load Efficiency:

    a. IPLV: <**Insert number**>.
    b. NPLV: <**Insert number**>.

4. Low Ambient Operation: Chiller designed for operation to minus 20 deg F (minus 29 deg C).
5. High Ambient Operation: Chiller designed for operation to 125 deg F (52 deg C).
6. Evaporator Configuration: [**Integral to chiller**] [**Shipped loose for remote field installation**].
7. Evaporator Pressure Rating: [**300 psig (2068 kPa)**] <**Insert value**>.
8. Evaporator Fluid Type: [**Water**] <**Insert fluid type**>.
9. Design Evaporator Fluid Flow Rate: <**Insert gpm (L/s)**>.
10. Minimum Evaporator Fluid Flow Rate: <**Insert gpm (L/s)**>.
11. Evaporator Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
12. Evaporator Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
13. Evaporator Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
14. Evaporator 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**>.
15. Condenser Entering-Air Temperature: <**Insert deg F (deg C)**>.
16. Site Altitude: <**Insert feet (m)**>.
17. Condenser Fan External Static Pressure: [**0.4-inch wg (100 Pa)**] [**1.0-inch wg (250 Pa)**].
18. Number of Refrigeration Circuits: Two.
19. Compressor Rated Load Amperes: <**Insert value**>.
20. Compressor Locked-Rotor Amperes: <**Insert value**>.
21. Controls Power Connection: [**Fed through integral transformer**] [**Separate field power connection**].

    a. Controls Power Input: <**Insert kilowatts**>.
    b. Controls Minimum Circuit Ampacity: <**Insert value**>.
    c. Controls Maximum Overcurrent Protection Device: <**Insert amperage**>.
    d. Controls Electrical Characteristics: [**120**] <**Insert value**>-V ac, single phase, 60 Hz.

22. Chiller Power Input: <**Insert kilowatts**>.

23. Chiller Minimum Circuit Ampacity: <**Insert value**>.
24. Chiller Maximum Overcurrent Protection Device: <**Insert amperage**>.
25. Chiller Electrical Characteristics: [**208**] [**240**] [**480**] [**600**] <**Insert value**>-V ac, three phase, 60 Hz.
26. Noise Rating: <**Insert dBA**> at <**Insert distance in feet (m)**> when measured according to ARI 370.

2.3 PACKAGED REFRIGERANT RECOVERY UNITS

A. Packaged portable unit shall consist 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 water chiller.

2.4 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to ARI 506/110, "Water Chilling Packages Using the Vapor Compression Cycle."

1. Allow [**Owner**] <**Insert entity**> access to place where water chillers are being tested. Notify Architect [**14**] <**Insert number**> days in advance of testing.

C. Factory test and inspect evaporator [**and water-cooled condenser**]according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located indoors, rate sound power level according to ARI 575 procedure.

E. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

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

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

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on support structure indicated.

B. Equipment Mounting:

1. Install water 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 water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

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

3.3 CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

D. 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 pressure gage,[**flow meter,**] and drain connection with valve. Make connections to water chiller with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].

E. 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 pressure gage,[**flow meter,**] and drain connection with valve. Make connections to water chiller with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].

F. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions.[**Comply with ASHRAE 15.**]

G. Connect each 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 if required.

3.4 STARTUP SERVICE

A. [**Engage a factory-authorized service representative to perform**] [**Perform**] startup service.

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

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-[**and condenser-**]water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

3.5 DEMONSTRATION

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

END OF SECTION 236419