

SECTION 23 64 23 - SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, water cooled, electric motor driven, scroll water chillers.
2. Packaged, air cooled, electric motor driven, scroll water chillers.

1.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance:** Scroll water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7. 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."

1.3 SUBMITTALS

- A. Product Data:** Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Certificates:** For certification required in "Quality Assurance" Article.
- C. Seismic Qualification Certificates:** For water chillers, accessories, and components from manufacturers.
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. Startup service reports.**
- E. Operation and maintenance data.**
- F. Warranty.**

1.4 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 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
- C. ASHRAE Compliance:
 - 1. ASHRAE 15 for safety code for mechanical refrigeration.
 - 2. ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.
- D. Seattle Energy Code for energy efficiency.
- E. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- F. Comply with NFPA 70.

1.5 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.

1.6 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 period.
 - 1. Compressor Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED WATER COOLED WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - 1. McQuay International.
 - 2. Trane.
 - 3. Carrier Corporation; a United Technologies company.
- 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 hermetically sealed casing.
 - 2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - 3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
 - 4. Capacity Control: On off compressor cycling [**plus hot-gas bypass**].
 - 5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
 - 6. Vibration Isolation: Mount individual compressors on vibration 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, two 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.
- G. Refrigeration:
 - 1. Refrigerant: R-134a. 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 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:
 - 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.
- 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 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.

K. Controls:

- 1. Standalone, 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.
- 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. Anti-recycling timer.
 - g. Automatic lead lag switching.
- 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.
- 6. Building Management System Interface: Factory installed hardware and software to enable building management system 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]** communication interface with building management system shall enable building management system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building management system.

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.
- 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 for each refrigeration circuit.
3. Factory-furnished neoprene isolators for field installation.

N. Characteristics:

1. Evaporator Type: Brazed plate or shell and tube.
2. Evaporator Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.
3. Condenser Type: Shell and tube.
4. Condenser Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu.
5. Number of Refrigeration Circuits: **[One]** **[Two]**.
6. Controls Power Connection: Fed through integral transformer.

2.2 PACKAGED AIR COOLED WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Carrier Corporation; a United Technologies company.
2. McQuay International.
3. Trane.
4. Petra Engineering Industries Co.
5. York International Corporation.

- 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.
2. Frame: Rigid galvanized steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
3. Casing: Galvanized steel.
4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500 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.

E. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
4. Capacity Control: On-off compressor cycling [**plus hot-gas bypass**].
5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
6. Vibration Isolation: Mount individual compressors on vibration isolators.

F. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-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.

H. Refrigeration:

1. Refrigerant: R-134a. 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-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. 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.
 - 4. Heater: Factory installed and wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.
 - 5. 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 on each circuit, rated at 450 psig. Construct coils of copper tubes mechanically bonded to aluminum fins.
 - 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, 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 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. Provide power factor correction capacitors to correct power factor to 0.97 at full load.
11. 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. 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.

L. Controls:

1. Standalone, 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. Anti-recycling timer status.
 - m. Percent of maximum motor amperage.
 - n. Current limit set point.
 - o. Number of compressor starts.
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. External water chiller emergency stop.
 - e. Antirecycling timer.
 - f. Automatic lead-lag switching.
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.

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.
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 water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
3. Factory furnished neoprene isolators for field installation.

O. Characteristics:

1. Low Ambient Operation: Chiller designed for operation to 0 deg F.
2. Evaporator Configuration: Integral to chiller.
3. Evaporator Pressure Rating: 150 psig.
4. Evaporator Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.
5. Number of Refrigeration Circuits: [**One**] [**Two**].
6. Controls Power Connection: Fed through integral transformer.

2.3 SOURCE QUALITY CONTROL

- A. Perform functional test of water chillers before shipping.
- B. Factory test and inspect evaporator according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
- C. 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: Install water chiller on concrete bases using elastomeric mounts. Concrete base is specified in Division 23 Section "Common Work Results for Mechanical" and concrete materials and installation requirements are specified in Division 03 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for Mechanical Piping and Equipment."
 - 1. Minimum Deflection: 1/4 inch.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around the full perimeter of concrete base.
 - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
- 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 Division 23 Section "Hydronic 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 pressure gage, and drain connection with valve. Make connections to water chiller with a union, 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 pressure gage and drain connection with valve. Make connections to water chiller with a union, flange, or mechanical coupling.
- E. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15.
- F. 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 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 proper motor rotation.
 - 7. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
 - 8. Verify and record performance of chilled-water flow and low-temperature interlocks.
 - 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 Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions.

END OF SECTION 23 64 23