SECTION 23 62 00 - BASE BID CHILLER

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Microprocessor-controlled liquid chiller shall use a semi-hermetic screw compressor using refrigerant HFC-134a only.

B. Carrier 23XRV Series or approved alternate.

1.2 QUALITY ASSURANCE

A. Chiller performance shall be rated in accordance with AHRI (Air-Conditioning, Heating and Refrigeration Institute) Standard 550/590, latest edition.

B. Equipment and installation shall be in compliance with ANSI/ASHRAE 15 (latest edition).

C. Cooler and condenser refrigerant side shall include ASME ‘U’ stamp and nameplate certifying compliance with ASME Section VIII, Division 1 code for unfired pressure vessels.

D. A manufacturer’s data report is required to verify pressure vessel construction adherence to ASME vessel construction requirements. Form U-1 as required per ASME code rules is to be furnished to the owner. The U-1 Form must be signed by a qualified inspector, holding a National Board Commission, certifying that construction conforms to the latest ASME Code Section VIII, Div. 1 for pressure vessels. The ASME symbol “U” must also be stamped on the heat exchanger. Vessels specifically exempted from the scope of the code must come with material, test, and construction methods certification and detailed documents similar to ASME U-1; further, these must be signed by an officer of the company.

E. Chiller shall be designed and constructed to meet UL and UL of Canada requirements and have labels appropriately affixed.

F. The management system governing the manufacture of this product is ISO (International Organization for Standardization) 9001:2008 certified.

G. Each compressor assembly shall undergo a mechanical run-in test to verify vibration levels, oil pressures, and temperatures are within acceptable limits. Each compressor assembly shall be proof tested at a minimum 204 psig and leak tested at 185 psig with a tracer gas mixture.

H. Entire chiller assembly shall be proof tested at 204 psig (1407 kPa) and leak tested at 185 psig (1276 kPa) with a tracer gas mixture on the refrigerant side. The leak test shall not allow any leaks greater than 0.5 oz (14.78 mL) per year of refrigerant. The water side of each heat exchanger shall be hydrostatically tested at 1.3 times rated working pressure.

I. Prior to shipment, the chiller automated controls test shall be executed to check for proper wiring and ensure correct controls operation.

J. Chillers shall have factory-mounted, factory-wired and factory-tested unit-mounted variable frequency drive (VFD). Proper VFD operation shall be confirmed prior to shipment.

K. Unit shall not exceed 86 DBA at full load when tested per AHRI Standard 575.

1.3 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled in accordance with manufacturer's instructions.

B. Unit shall be shipped with all refrigerant piping and control wiring factory installed.

C. Unit shall be shipped charged with oil and full charge of refrigerant HFC-134a or a nitrogen holding charge as specified on the equipment schedule.

D. Unit shall be shipped with firmly attached labels that indicate name of manufacturer, chiller model number, chiller serial number, and refrigerant used.

E. If the unit is to be exported, the manufacturer shall provide sufficient protection against sea water corrosion, making the unit suitable for shipment in a standard open top ocean shipping container.

F. Chiller and starter shall be stored indoors, protected from construction dirt and moisture. Chiller shall be inspected under shipping tarps, bags, or crates to be sure water has not collected during transit. Protective shipping covers shall be kept in place until machine is ready for installation. The inside of the protective cover shall meet the following criteria:
   1. Temperature is between 40 F and 120 F.
   2. Relative humidity is between 10% and 80% non-condensing.

1.4 WARRANTY

A. Warranty shall include parts and labor for one year after start-up or 18 months from shipment, whichever occurs first. A refrigerant warranty shall be provided for a period of 5 years.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. General:
   1. Factory-assembled, single piece, liquid chiller shall consist of compressor, motor, VFD, lubrication system, cooler, condenser, initial oil and refrigerant operating charges, microprocessor control system, and documentation required prior to start-up.

B. Compressor:
   1. One variable speed screw compressor of the high performance type.
   2. Compressor and motor shall be hermetically sealed into a common assembly and arranged for easy field servicing.

3. The compressor motor shall be accessible for servicing without removing the compressor base from the chiller. Connections to the compressor casing shall use O-rings and gaskets to reduce the occurrence of refrigerant leakage. Connections to the compressor shall be flanged or bolted for easy disassembly.
4. Compressor bearings must have individual design life of 50 years or greater when operating at AHRI conditions.
5. Compressor shall provide capacity modulation from 100% to 15% capacity without the use of hot gas bypass or mechanical unloaders.
6. Compressor shall be provided with a factory installed positive pressure lubrication system to deliver oil under pressure to bearings and rotors at all operating conditions. Lubrication system shall include:
    a. Oil pump with factory-installed motor contactor with overload protection.
    b. Oil pressure sensor with differential readout at main control center.
    c. Oil pressure regulator.
    d. Oil filter with isolation valves to allow filter change without removal of refrigerant charge.
    e. Oil sump heater 115 v, 60 Hz controlled from unit microprocessor.
    f. Oil reservoir temperature sensor with main control center digital readout.
    g. All wiring to oil pump, oil heater, and controls shall be pre-wired in the factory and power shall be applied to check proper operation prior to shipment.
    h. Compressor shall be fully field serviceable. Compressors that must be removed and returned to the factory for service shall be unacceptable.
    i. Acoustical attenuation shall be provided as required, to achieve a maximum (full load) sound level, measured per AHRI Standard 575 (latest edition).

C. Motor:
1. Compressor motor shall be of the semi- hermetic, liquid-refrigerant-cooled, squirrel-cage, induction-type suitable for voltage shown on the equipment schedule. Air cooled motors or open motors are not allowed.
2. If an open (air-cooled) motor is provided, a compressor shaft seal leakage containment system shall be provided:
    a. An oil reservoir shall collect oil and refrigerant that leaks past the seal.
    b. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing.
    c. A refrigerant sensor shall be located next to the open drive seal to detect leaks.
3. Motors shall be suitable for operation in a refrigerant atmosphere and shall be cooled by atomized refrigerant in contact with the motor windings.
4. Motor stator shall be arranged for service or removal with only minor compressor disassembly and without removing main refrigerant piping connections.
5. Full load operation of the motor shall not exceed nameplate rating.
6. One motor winding temperature sensor (and one spare) shall be provided.

D. Evaporator and Condenser:

1. Evaporator and condenser shall be of shell and tube type construction, each in separate shells. Units shall be fabricated with high-performance tubing, steel shell and tube sheets with waterboxes. Waterboxes shall be nozzle-in-head type with stub out nozzles having Victaulic grooves to allow for use of Victaulic couplings.
2. Tubing shall be copper, high-efficiency type, with integral internal and external enhancement unless otherwise noted. Tubes shall be nominal $^{3}/_{4}$-in. OD with nominal wall thickness of 0.025 in. measured at the root of the fin unless otherwise noted. Tubes shall be rolled into tube sheets and shall be individually replaceable. Tube sheet holes shall be double grooved for joint structural integrity. Intermediate support sheet spacing shall not exceed 36 in. (914 mm).
3. Waterboxes and nozzle connections shall be designed for 150 psig (1034 kPa) minimum working pressure unless otherwise noted. Nozzles should have grooves to allow use of Victaulic couplings.
4. The tube sheets of the cooler and condenser shall be bolted together to allow for field disassembly and reassembly.
5. The vessel shall display an ASME nameplate that shows the pressure and temperature data and the 'U' stamp for ASME Section VIII, Division 1. A re-seating pressure relief valve(s) shall be installed on each heat exchanger. If a non-reseating type is used, a backup reseating type shall be installed in series.
6. Waterboxes shall have vents, drains, and covers to permit tube cleaning within the space shown on the drawings. A thermistor-type temperature sensor with quick connects shall be factory installed in each water nozzle.
7. Cooler shall be designed to prevent liquid refrigerant from entering the compressor. Devices that introduce pressure losses (such as mist eliminators) shall not be acceptable because they are subject to structural failures that can result in extensive compressor damage.
8. Tubes shall be individually replaceable from either end of the heat exchanger without affecting the strength and durability of the tube sheet and without causing leakage in adjacent tubes.
9. The subcooler, located in the bottom of the condenser, shall increase the refrigeration effect by cooling the condensed liquid refrigerant to a lower temperature, thereby reducing compressor power consumption.

E. Refrigerant Flow Control:
   1. The variable flow control system regulates refrigerant flow according to load conditions, providing a liquid seal at all operating conditions, eliminating unintentional hot gas bypass.

F. Controls, Safeties, and Diagnostics:
   1. Controls:
      a. The chiller shall be provided with a factory-installed and factory-wired microprocessor control center. The control center shall include a 16-line by 40-character liquid crystal display, 4 function keys, stop button, and alarm light. Other languages are available using the international language translator software.
      b. All chiller and motor control monitoring shall be displayed at the chiller control panel.
      c. The controls shall make use of non-volatile memory.
      d. The chiller control system shall have the ability to interface and communicate directly to the building control system.

e. The default standard display screen shall simultaneously indicate the following minimum information:
   1) Date and time of day
   2) 24-character primary system status message
   3) 24-character secondary status message
   4) Chiller operating hours
   5) Entering chilled water temperature
   6) Leaving chilled water temperature
   7) Evaporator refrigerant temperature
   8) Entering condenser water temperature
   9) Leaving condenser water temperature
   10) Condenser refrigerant temperature
   11) Oil supply pressure
   12) Oil sump temperature
   13) Percent motor rated load amps (RLA)

f. In addition to the default screen, status screens shall be accessible to view the status of every point monitored by the control center, including:
   1) Evaporator pressure
   2) Condenser pressure
   3) Compressor speed
   4) Bearing oil supply temperature
   5) Compressor discharge temperature
   6) Motor winding temperature
   7) Number of compressor starts
   8) Control point settings
   9) Discrete output status of various devices
   10) Variable frequency drive status
   11) Optional spare input channels
   12) Line current and voltage for each phase
   13) Frequency, kW, kWhr, demand kW

g. Schedule Function: The chiller controls shall be configurable for manual or automatic start-up and shutdown. In automatic operation mode, the controls shall be capable of automatically starting and stopping the chiller according to a stored user programmable occupancy schedule. The controls shall include built-in provisions for accepting:
   1) A minimum of two 365-day occupancy schedules.
   2) Minimum of 8 separate occupied/unoccupied periods per day
   3) Daylight savings start/end
   4) 18 user-defined holidays
   5) Means of configuring an occupancy timed override
   6) Chiller start-up and shutdown via remote contact closure

h. Service Function: The controls shall provide a password--protected service function that allows authorized individuals to view an alarm history file, which shall contain the last 25 alarm/alert messages with time and date stamp. These messages shall be displayed in text form, not codes.

i. Network Window Function: Each chiller control panel shall be capable of viewing multiple point values and statuses from other like controls connected on a common network, including controller maintenance data. The operator shall be able to alter the remote controller's set points or time schedule and to force point values or statuses for those points that are operator forcible. The control panel shall also have access to the alarm history file of all like controllers connected on the network.

j. Pump Control: Upon request to start the compressor, the control system shall start the chilled and condenser water pumps and shall verify that flows have been established.

k. Ramp Loading: A user-configurable ramp loading rate, effective during the chilled water temperature pulldown period, shall prevent a rapid increase in compressor power consumption. The controls shall allow configuration of the ramp loading rate in either degrees per minute of chilled water temperature pulldown or percent motor amps per minute. During the ramp loading period, a message shall be displayed informing the operator that the chiller is operating in ramp loading mode.

l. Chilled Water Reset: The control center shall allow reset of the chilled water temperature set point based on any one of the following criteria:
   1) Chilled water reset based on an external 4 to 20 mA signal.
   2) Chilled water reset based on a remote temperature sensor (such as outdoor air).
   3) Chilled water reset based on water temperature rise across the evaporator.

m. Demand Limit: The control center shall limit amp draw of the compressor to the rated load amps or to a lower value based on one of the following criteria:
   1) Demand limit based on a user input ranging from 40% to 100% of compressor rated load amps
   2) Demand limit based on external 4 to 20 mA signal.

n. Controlled Compressor Shutdown: The controls shall be capable of being configured to soft stop the compressor. The display shall indicate "shutdown in progress."

2. Safeties:

a. Unit shall automatically shut down when any of the following conditions occur (each of these protective limits shall require manual reset and cause an alarm message to be displayed on the control panel screen, informing the operator of the shutdown cause):
   1) Motor overcurrent
   2) Over voltage*
   3) Under voltage*
   4) Single cycle dropout* (LF-2 VFDs only)
   5) Low oil sump temperature
   6) Low evaporator refrigerant temperature
   7) High condenser pressure
   8) High motor temperature
   9) High compressor discharge temperature
   10) Low oil pressure
   11) Prolonged stall
   12) Loss of cooler water flow

13) Loss of condenser water flow
14) Variable frequency drive fault
15) High variable frequency drive temperature

* Shall not require manual reset or cause an alarm if auto-restart after power failure is enabled.

b. The control system shall detect conditions that approach protective limits and take self-corrective action prior to an alarm occurring. The system shall automatically reduce chiller capacity when any of the following parameters are outside their normal operating range:
   1) High condenser pressure
   2) High motor temperature
   3) Low evaporator refrigerant temperature
   4) High motor amps
   5) High VFD inverter temperature

c. During the capacity override period, a pre-alarm (alert) message shall be displayed, informing the operator which condition is causing the capacity override. Once the condition is again within acceptable limits, the override condition shall be terminated and the chiller shall revert to normal chilled water control. If during either condition the protective limit is reached, the chiller shall shut down and a message shall be displayed informing the operator which condition caused the shutdown and alarm.

d. Internal built-in safeties shall protect the chiller from loss of water flow. Differential pressure switches shall not be allowed to be the only form of freeze protection.

3. Diagnostics and Service:
   a. A self-diagnostic controls test shall be an integral part of the control system to allow quick identification of malfunctioning components.
   b. Once the controls test has been initiated, all pressure and temperature sensors shall be checked to ensure they are within normal operating range. A pump test shall automatically energize the chilled water pump, condenser water pump, and oil pump. The control system shall confirm that water flow and oil pressure have been established and require operator confirmation before proceeding to the next test.
   c. In addition to the automated controls test, the controls shall provide a manual test, which permits selection and testing of individual control components and inputs. A thermistor test and transducer test shall display on the ICVC screen the actual reading of each transducer and each thermistor installed on the chiller. All out-of-range sensors shall be identified. Pressure transducers shall be serviceable without the need for refrigerant charge removal or isolation.

4. Multiple Chiller Control: The chiller controls shall be supplied as standard with a 2-chiller lead/lag and a third chiller standby system. The control system shall automatically start and stop a lag or second chiller on a 2-chiller system. If one of the 2 chillers on line goes into a fault mode, the third standby chiller shall be automatically started. The 2-chiller lead/lag system shall allow manual rotation of the lead chiller and a staggered restart of the chillers after a power failure. The lead/lag system shall include load balancing if configured to do so.

5. BACnet* Communication Option: Shall provide factory-installed communication capability with a BACnet MS/TP network. Allows integration with i-Vu® Open control system or a BACnet building automation system.

G. Electrical Requirements:
1. Electrical contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, and electrical protection devices per local code requirements and as indicated necessary by the chiller manufacturer.
2. Electrical contractor shall wire the chilled water pump and flow, condenser water pump and flow, and tower fan control circuit to the chiller control circuit.
3. Electrical contractor shall supply and install electrical wiring and devices required to interface the chiller controls with the building control system if applicable.
4. Electrical power shall be supplied to the unit at the voltage, phase, and frequency listed in the equipment schedule.

H. Piping Requirements — Instrumentation and Safeties:
1. Mechanical contractor shall supply and install pressure gages in readily accessible locations in piping adjacent to the chiller such that they can be easily read from a standing position on the floor. Scale range shall be such that design values shall be indicated at approximately mid-scale.
2. Gages shall be installed in the entering and leaving water lines of the cooler and condenser.

I. Vibration Isolation: Chiller manufacturer shall furnish neoprene isolator pads for mounting equipment on a level concrete surface.

J. Start-Up:
1. The chiller manufacturer shall provide a factory-trained representative, employed by the chiller manufacturer, to perform the start-up procedures as outlined in the Start-Up, Operation and Maintenance manual provided by the chiller manufacturer.
2. Manufacturer shall supply the following literature:
   a. Start-up, operation and maintenance instructions.
   b. Installation instructions.
   c. Field wiring diagrams.
   d. One complete set of certified drawings.

K. Special Features:
1. Refrigerant Charge: The chiller shall ship from the factory fully charged with R-134a refrigerant and oil.
2. Thermal Insulation: Unit manufacturer shall insulate the cooler shell, economizer, suction elbow, motor shell, and motor cooling lines. Insulation shall be 1 in. (25.4 mm) thick with a thermal conductivity not exceeding and shall conform to UL standard 94, classification 94 HF-1.

$$0.28 \quad \frac{(\text{Btu} \cdot \text{in.})}{\text{hr. Ft}^2\ \text{F}} \quad \left(\quad 0.0404 \quad \frac{\text{W}}{\text{m C}} \right)$$

3. Automatic Hot Gas Bypass: Hot gas bypass valve and piping shall be factory-furnished to permit chiller operation for extended periods of time.
4. Unit-Mounted Variable Frequency Drive (VFD) with Built-In Harmonic LiquiFlo™ II Filter (Q and R compressor only):
    a. Design:
        1) The VFD shall be refrigerant cooled, microprocessor-based, pulse width modulated design. Water-cooled designs are not acceptable.
        2) Input and output power devices shall be Insulated Gate Bipolar Transistors (IGBTs).
        3) Rectifier shall convert incoming fixed voltage/frequency to fixed DC voltage.
        4) Transistorized inverter and control regulator shall convert fixed DC voltage to a sinusoidal PWM waveform.
        5) Low voltage control sections and main power sections shall be physically -isolated.
        6) Integrated controls shall coordinate motor speed to optimize chiller performance over a wide variety of operating conditions.
    b. Enclosure:
        1) Pre-painted, unit-mounted NEMA (National Electrical Manufacturers Association) 1 cabinet shall include hinged, lockable doors and removable lifting lugs.
        2) The VFD shall have a short circuit current rating of at least 65,000 amps.
        3) Provisions to padlock main disconnect handle in “Off” positions shall be provided. Mechanical interlock to prevent opening cabinet door with disconnect in the “On” position or moving disconnect to the “On” position while the door is open shall be provided.
        4) Provisions shall be made for top entry of incoming line power cables.
    c. Heat Sink:
        1) The heat sink (frame sizes 3, 4, 5 heat exchangers only) shall be refrigerant cooled. Heat sink and mating flanges shall be suitable for ASME design working pressure of 185 psig.
        2) Refrigerant cooling shall be metered to maintain heat sink temperature within acceptable limits for ambient temperature.
    d. VFD Rating:
        1) Drive shall be suitable for operation at nameplate voltage ±10%.
        2) Drive shall be suitable for continuous operation at 100% of nameplate amps and 150% of nameplate amps for -5 seconds.
        3) Drive shall comply with applicable ANSI, NEMA, UL (Underwriters Laboratories) and NEC (National Electrical Code) standards.

4) Drive shall be suitable for operation in ambient temperatures between 40 and 122 F, 95% humidity (non-condensing) for altitudes up to 6000 ft above sea level. Specific drive performance at jobsite ambient temperature and elevation shall be provided by the manufacturer in the bid.

e. User Interface: A single display shall provide interface for programming and display of VFD and chiller parameters. Viewable parameters include:
1) Operating, configuration, and fault messages
2) Frequency in Hz
3) Load and line side voltage and current (at the VFD)
4) kW
5) IGBT temperature

f. VFD Performance:
1) The VFD Voltage Total Harmonic Distortion (THD) and Harmonic Current Total Demand Distortion (TDD) shall not exceed IEEE-519 requirements using the VFD circuit breaker input terminals as the point of common coupling (PCC).
2) The VFD full load efficiency shall meet or exceed 97% at 100% VFD rated ampacity.
3) Active rectifier shall regulate unity displacement power factor to 0.99 or higher.
4) Voltage boost capability to provide full motor voltage at reduced line voltage conditions.
5) The VFD shall feature soft start, linear acceleration, and coast to stop capabilities.
6) Base motor frequency shall permit motor to be utilized at nameplate voltage. Adjustable frequency range shall permit capacity control down to 15%.
7) The VFD shall have 150% instantaneous torque generation.

g. VFD Electrical Service (single point power):
1) The VFD shall have input circuit breaker with minimum 65,000 amp interrupt capacity.
2) The VFD shall have standard branch oil pump circuit breaker to provide power for chiller oil pump.
3) The VFD shall have standard 3 KVA control power transformer with circuit breaker to provide power for oil heater, VFD controls, and chiller controls.
4) The branch oil pump circuit breaker and control power transformer shall be factory wired.
5) Input power shall be 460 vac, ±10%, 3 Phase, 60 Hz, ±2% Hz.

h. Discrete Outputs: 115-v discrete contact outputs shall be provided for:
1) Circuit breaker shunt trip
2) Chilled water pump
3) Condenser water pump
4) Alarm status

i. Analog Output: An analog (4 to 20 mA) output for head pressure reference shall be provided. This signal shall be suitable to control a 2-way or 3-way water regulating valve in the condenser piping.

j. Protection (the following shall be supplied):

1) Under-voltage
2) Over voltage
3) Phase loss
4) Phase reversal
5) Ground fault
6) Phase unbalance protection
7) Single cycle voltage loss protection (LF-2 VFD only)
8) Programmable auto re-start after loss of power
9) Motor overload protection (NEMA Class 10)
10) Motor over temperature protection

k. VFD Testing: The VFD shall be factory mounted, factor wired and factory tested on the chiller prior to shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive chillers for compliance with installation tolerances and other conditions effecting performance and maintenance of chillers.

B. Examine proposed route of moving chillers into place and verify that it is free of interferences.

C. Verify piping roughing-in locations.

D. Verify branch circuit wiring suitability. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PIPING SYSTEM FLUSHING PROCEDURE

A. Prior to connecting chillers to water loops or after connections with the manual valves in the closed position, the piping shall be flushed with a detergent & hot water mixture to remove previously accumulated dirt and other organic.

B. During flushing any strainers in the system shall be examined periodically and cleaned when required. The flushing process should take no less than 6 hours or until the strainers when examined after each flush are clean. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.

3.3 WATER TREATMENT REQUIREMENTS

A. Both water loops shall be analyzed and treated by a professional water treatment specialist to ensure brazed plate heat exchanger longevity by keeping the water within the following parameters:

1. Sulfates	Less than 200 ppm
2. pH	7.0 – 9.0
3. Chlorides	Less than 200 ppm
4. Nitrate	Less than 100 ppm
5. Iron	Less than 4.5 mg/l
6. Ammonia	Less than 2.0 mg/l

7. Manganese Less than 0.1 mg/l
8. Total Dissolved Solids (TDS) Less than 1000 mg/l
9. Hardness as $CaCO_3$ 30 to 500 ppm
10. Alkalinity as $CaCO_3$ 30 to 500 ppm

Equipment manufacturer shall provide sample bottles and have analysis done at time of start-up of equipment. Owner is responsible for maintaining proper parameters.

3.4 INSTALLATION

A. Install chillers according to manufacturer's written instructions.

B. Install chillers plumb and level, and anchor housekeeping pads to building floor. Anchor chiller and vibration isolators to housekeeping pad.

C. Install vibration isolators according to isolator manufacturer's written instructions.

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

E. Install piping connections maintaining clearances for service and maintenance of chillers.

F. Install differential pressure switches across chilled-water and condenser-water connections.

G. Install flange connections at chillers.

H. Install flexible pipe connections for chillers mounted on vibration isolators.

I. Install MAIN shutoff valves at chiller inlet and outlet of both chilled-water and condenser-water connections.

J. Install BYPASS MAIN shutoff valves which can short-circuit chiller inlet to outlet of both chilled-water and condenser-water connections.

K. Install water strainers as required to the evaporator and condenser water systems.

3.5 ELECTRICAL CONNECTIONS

A. Install all necessary electrical wiring devices and services such as fused disconnect switches or circuit breakers to power each module, phase loss monitors. Install all wires and cables routing between each module and the master controller. Install electrical service to the master control panel. All wiring is done in the field and shall be according to local and national electrical codes where applicable.

B. Install and connect remote flow switches, temperature sensors, and remote chiller control panel.

C. Ground equipment.

D. Tighten electrical connectors and terminals, including grounding connections, according to manufacturers published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B_

3.6 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.7 CLEANING

A. Clean finishes to remove dust and dirt.

B. Touch up scratches in unfinished surfaces to restore corrosion resistance.

C. Touch up scratches in finished surfaces to restore finish.

3.8 START-UP

A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to A/E in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer's IOM.

B. Engage a factory authorized service representative to perform startup service. Verify water source for compliance with manufacturer's requirements for flow and temperature. Measure and record electrical values for voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing" and comply with provisions therein.

C. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

3.9 DEMONSTRATION

A. Factory-Authorized Startup Services: Engage a factory-authorized service representative to supervise startup services performed by an independent mechanical contractor provided by the Owner, and to demonstrate and train Owner's maintenance personnel as specified below.

B. Train the Owner's maintenance personnel on procedures and schedules related to startup, shutdown, troubleshooting, servicing, and preventive maintenance.

C. Review data in the operation and maintenance manuals.

END OF SECTION