SECTION 23 64 16 - CENTRIFUGAL CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

A. Work Included: Provide water-cooled centrifugal water chillers and components as shown, scheduled, and indicated on the Drawings, including but not limited to:

1. Chiller package.
2. Charge of refrigerant and oil.
3. Controls and control connections.
4. Chilled water connections.
5. Condenser water connections.
6. Starters.
7. Electrical power connections.

1.3 QUALITY ASSURANCE:

A. Manufacturers: the design shown on the drawings is based upon products of the manufacturer scheduled. Equipment manufactured by Carrier, **[McQuay (part of Daikin Industries)]**, Trane or York will be acceptable if it meets the scheduled capacities and complies with these specifications. If equipment manufactured by a manufacturer other than that scheduled is utilized, then the Mechanical Contractor shall be responsible for coordinating with the General Contractor and all affected Subcontractors to insure proper provisions for installation of the furnished unit. This coordination shall include, but is not limited to, the following:

1. Structural supports for units.
2. Piping size and location.
3. Electrical power requirement and wire, conduit and overcurrent protection sizes.
4. The Mechanical Contractor shall be responsible for all costs incurred by the General Contractor, Subcontractors and Consultants to modify the building provisions to accept the furnished units.

B. Standards: Products shall be designed, tested, rated, and installed in compliance with the following standards, as applicable.

1.	ANSI/ASHRAE STANDARD 15-1978	Safety Code for Mechanical Refrigeration.
2.	ANSI/ASHRAE 90A	Energy Conservation in New Building Design.
3.	ANSI/ASME SEC VIII	Boiler and Pressure Vessel Code.
4.	ANSI/ASME B31.S-1983	ASME Code for Pressure Piping and Refrigeration Piping.
5.	ANSI/UL 465	Central Cooling Air Conditioners.
6.	UL 984	Safety Standards for Hermetic Motor Compressors.
7.	ARI STANDARD 550-90	Centrifugal or Rotary Water Chilling Packages.
8.	AFBMA 9	Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.

C. Ratings and Certifications: Products shall be rated and certified in accordance with the following:

1. Conform to ARI Standard 550-90 code for rating and testing of centrifugal chillers.
2. Conform to ANSI/UL 465 for construction of centrifugal chillers **[and provide UL label]**.

3. Conform to ANSI/ASME Section VIII Boiler and Pressure Vessel Code for construction and testing of centrifugal chillers.
4. Conform to ANSI/ASHRAE Standard 15-1978 code for construction and operation of centrifugal chillers.
5. Unit shall bear the ARI certification label for centrifugal water-cooled chillers as applicable.

D. [Factory Performance Testing: One chiller of each size specified for the project shall be factory performance tested under full load conditions in an ARI-certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer. The performance test shall be conducted in accordance with ARI Standard 550-90 procedures and tolerances.

1. **The performance test shall be run with clean tubes in accordance with ARI 550-90 to include the following:**
   a. **A downward temperature adjustment per Section A7.3 shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.**
   b. **An upward temperature adjustment per Section A7.3 shall be made to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.**
   c. **Test temperature adjustments can be verified prior to test by the Vice President, Engineering, ARI. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments in Paragraph a. and Paragraph b. The manufacturer shall clean tubes, if necessary, prior to test to obtain a test fouling factor of 0.0000 hr. sq. ft. F/BTU.**
   d. **Factory performance testing shall include integrated part load value (IPLV) testing. Test reports provided with O&M Manuals shall include raw data used in IPLV calculations.**
2. **The factory test instrumentation shall be per ARI Standard 550, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology (formerly NBS).**

[VERIFY IF A WITNESSED TEST IS REQUIRED]

3. **The Owner or his Representative shall be notified 14 days in advance to witness the factory performance test. If the Owner or his Representative desires to witness the performance test, all travel expenses will be the Owner's responsibility.**
4. **A certified test report of all data shall be submitted to the Engineer prior to shipping of chillers to the job site. The factory-certified test report shall be signed by an officer of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.**
5. **Equipment will be accepted if the test procedures and results are in conformance with ARI Standard 550-90. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Owner or his Representative to witness the retest. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed:**
   a. **Capacity Test: For each ton below the allowable capacity as set forth in ARI 550-90 of the design capacity, five hundred dollars ($500.00) per ton will be deducted from the contract price.**

      Allowable capacity = (1 - tolerance) x design capacity; tolerance per ARI 550-90, Section 5.4.

b. Power Consumption Test: The power consumption penalty for all load points shall be based upon the tolerances set forth in ARI 550-90. The power consumption penalty (P.C.P.) will be calculated based upon the following formula:

P.C.P. = [Measured kW - (Measured Tons x Allowable kW/Ton*)] x $1000/kW

*** Allowable KW/Ton = (1 + tolerance) x design kW/Ton; tolerance per ARI 550-88, Section 5.4.**

c. Total Performance Penalty: The total performance penalty will be the sum of Capacity Penalty and Power Consumption Penalty, times the number of typical chillers, regardless of whether all chillers are tested.

6. **Equipment manufacturer shall not invoice for the centrifugal chillers(s) until successful completion of the performance test or acceptance of penalty deduction from the contract.]**

E. Warranty: Provide [two] [five] [_____] year warranty for chillers including coverage for [compressor] [compressor motor] [evaporator] [condenser] [complete chiller package] [gear box] [refrigerant metering system] as manufactured and delivered to site including [materials] [and labor] [only].

F. Maintenance Service: Provide service and maintenance of chillers for period of [one] [two] [five] [_____] years from Date of Substantial Completion. Manufacturer shall have local stock of parts for centrifugal chillers proposed. Manufacturer shall have local service organization which shall have been established for at least 5 years.

1.4 SUBMITTALS:

A. Shop drawing submittals shall include, but not be limited to, the following:

1. Drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.
2. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
3. Written description of equipment functions and normal operating characteristics.
4. Written operating instructions including check-out, adjustment, start-up, routine and normal operations, regulations and controls, and shutdown for emergency.
5. Written instructions for installation and assembly, where required, including assembly drawings showing match-marking of field-assembled components.
6. Chiller starter cut sheets with components, features, options, and wiring clearly indicated.
7. Motor data as specified in Section 23 04 00, "Motors and Controllers".
8. Wiring diagrams showing power and control wiring for chiller components, safety devices, and controls, clearly indicating both factory and field wiring.
9. Written listing of limiting conditions of chiller including minimum permissible temperatures, minimum voltages, maximum and minimum permitted ambient conditions, maximum permitted chilled-water-entering temperature, recommended thermal shock, and change-over temperatures.
10. Performance certifications and certified reports.
11. Warranties and guarantees.
12. Additional information as specified in Section 23 01 00.

1.5 HANDLING:

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

PART 2 - PRODUCTS

2.1 CHILLER MATERIALS AND COMPONENTS:

A. General: Provide chiller manufacturer's standard materials and components as indicated by his published product information, designed and constructed as recommended by the manufacturer and as required for a complete chiller installation as specified herein.

B. Selection: Each chiller shall allow for a water side fouling factor of 0.00025 in the evaporator tubes and **[0.00075] [0.001]** in the condenser tubes. Evaporator and condenser water pressure drops shall not exceed those scheduled on the Drawings. The total kW power consumption of the units shall not exceed the scheduled kW on the Drawings **[and will be] [field-] [factory-]** verified in the chiller capacity test specified **[herein] [in Section 15675, "Chiller Field Capacity Testing"]**. Chillers shall be rated in accordance with the latest edition of ARI Standard 550-90 and shall conform to ASHRAE/ANSI 15-1978 Safety Codes.

C. [Refrigerants: Chillers shall be provided for use with [R-123 or R-134a].

D. Efficiency: Chiller full load efficiency shall be equal to or greater than that scheduled.

E. Chillers: Shall consist of, but not be limited to, a complete system with compressor, motor, evaporator, condenser, lubrication system, purge system or pumpout unit, economizer or subcooler, capacity controller, instrument and control panel, unit mounted motor starter, factory-installed insulation and other items as specified herein or required.

2.2 COMPRESSORS AND MOTORS:

A. Compressors: Shall be direct drive or gear driven, single or multistage centrifugal type. Capacity control shall be provided by fully modulating variable inlet guide vanes and shall allow capacity modulation from 100% of scheduled capacity to 15% of scheduled capacity at scheduled design conditions and with condenser water temperatures down to 65°F**[, without hot gas bypass]**. Guide vanes shall be controlled by an externally mounted electric operator in response to the refrigeration load on the evaporator. Impellers shall be high strength aluminum alloy and shall be directly connected to the motor shaft or gear driven. Compressor bearings shall be hydrodynamic sleeve type or tapered roller bearings. Sleeve bearings shall be either aluminum insert or steel backed babbit. Tapered roller bearings shall be stainless steel. The entire motor/compressor assembly shall be statically and dynamically balanced and tested at 25% overspeed. The motor/compressor assembly on direct driven units or motor/gearbox/compressor assembly on gear driven units shall be balanced to a maximum vibration amplitude of one mil as measured on the motor/compressor housing. All compressor casings shall be cast iron and shall be proof-tested at 1.5 times the maximum working pressure and leak-tested with refrigerant trace gas.

B. Transmissions: If the compressor requires a speed-increasing transmission, it shall be hermetically sealed with the motor/compressor. The transmission shall be self-aligning with a parallel double helical gear arrangement having a minimum service factor of 1.2. If the thrust of the gears is counteracted by the design residual thrust of the impellers, single helix gear design will be acceptable. Each assembled compressor motor (transmission) shall be run-tested at the factory. At any bearing, neither the horizontal nor vertical vibration shall exceed 1.0 mil. Prior to installation, the manufacturer shall provide certified test results.

C. Motors: Shall be hermetically sealed low-slip squirrel cage induction motors designed and guaranteed for continuous operation at nameplate rating. Motors shall be cooled with liquid or suction refrigerant circulated directly over the starter windings and between the rotor and starter. All motor windings shall be designed for operation in a refrigerant atmosphere. The motor shall be suitable for **[SCR controlled solid-state or] [Star-Delta reduced voltage]** starting at the voltage scheduled on the drawings. Motor winding temperature sensors, interlocked for unit shutdown, shall be provided for each phase.

D. [Open-drive Option: At the Contractor's option, open-drive equipment may be furnished in lieu of the specified hermetic equipment provided the following conditions are strictly met.]

1. **[Heat rejected to the Central Plant shall be removed by air handling unit(s) complete with chilled water cooling coils, valves, piping, controls and other required components provided at no additional cost to the Owner.]**
2. **[Self-generated noise characteristics shall not exceed 78 dbA at full load, 81.5 dbA at 50% load and 81.5 dbA at 25% load.]**

3. **[Power consumption shall not exceed that of the specified hermetic machines over full operating range (15% to 100%), given constant 85°F to 95°F condenser water temperature.]**

E. Lubrication: Force-feed lubrication shall be provided by a direct drive, positive displacement oil pump which shall provide positive lubrication to all bearings at all times. Power for the oil pump shall be supplied through the control power transformer/source. A lubrication oil filter with a differential pressure gauge shall be provided. A low voltage-density oil heater shall maintain oil temperature at a level to minimize its affinity for refrigerant. Power for the oil heater shall be supplied from a separate control power circuit and wired through the unit control panel. An integral or independent oil cooling system shall be provided. An interlock shall be provided to prevent motor starting unless oil pressure is established.

2.3 VESSELS AND ACCESSORIES:

A. Evaporator and Condenser Vessels: Heat exchangers shall be of a shell and tube type designed in accordance with ANSI/ASHRAE 15-1978 Safety Code for Mechanical Refrigeration and ASME Code for Unfired Pressure Vessels and shall be appropriately stamped where required by ASME Code. The refrigerant side shall be proof tested 1.5 times the maximum design working pressure. The waterside working pressure shall be **[150] [300]** psi and shall be tested at 1.5 times design working pressure. Heat exchangers shall include water side taps for vent and drain connections as required. Waterside pressure drop shall not exceed scheduled values. Water side heads shall be removable to allow direct access to all tubes. Provide flanged connections with ANSI **[125] [150] [250]** pounds drilling for all heat exchanger supply and return piping.

B. Evaporator: The evaporator shell shall be formed of carbon steel plate and shall incorporate a carbon rupture disc. The evaporator relief shall be piped through the building roof in conformance with applicable codes or as shown on the drawings. The chiller manufacturer shall be responsible for sizing the relief piping. End and intermediate tube sheets shall be carbon steel and shall be drilled for tube installation. Tube sheets shall be welded to the vessel shell and be fully self-supporting. Tubes shall be **[externally finned] [internally enhanced]** nominal 0.028" wall copper tubing mechanically expanded into the tube sheets. Tubes shall be individually cleanable and replaceable. Mesh screen eliminators shall be installed along the entire length of the evaporator to prevent liquid refrigerant carry over into the compressor. Liquid refrigerant entering the evaporator shall be distributed uniformly along its entire length without direct impingement of high velocity refrigerant on tubes. For standard water selections, minimum allowable refrigerant temperatures shall be 32°F at the design conditions scheduled with a minimum water side tube temperature of 33.5°F. The refrigerant side of the evaporator shall be vacuum and pressure leak tested with refrigerant trace gas. The evaporator shall be tested as specified hereinabove for Evaporator and Condenser Vessels. Provide a site glass at each evaporator, located such that the proper refrigerant change is near the center of the glass with the unit off.

C. Refrigerant Flow Control: Shall be by means of a positive metering device and the chiller shall be capable of starting and operating with entering condenser water at 65°F. Adjustable or float type refrigerant metering devices and thermal expansion valves shall be inspected and adjusted by the manufacturer annually for the first 5 years of operation to assure equivalent reliability to a fixed orifice system.

D. Condenser: The condenser shell and tube sheets shall be formed of carbon steel plate. Condenser tubes shall be **[externally finned, internally smooth nominal 0.028"] [internally enhanced nominal 0.035"]** wall copper and shall be mechanically expanded into the tube sheets **[and shall be compatible with the Brush Cleaning System specified elsewhere in these specifications]**. Tubes shall be cleanable and replaceable. The condenser shall be tested as specified hereinabove for the Evaporator and for Evaporator and Condenser Vessels.

E. Economizer: An economizer may be incorporated to help maintain the correct differential between condensing and evaporator pressures over the entire range of loading. All units utilizing subcooling must be provided with a thermometer well to monitor the amount of subcooling.

F. Purge System: An automatic high efficiency purge system shall be provided on low pressure refrigerant (R-123, etc.) units to remove any noncondensables and water vapor present in the

refrigerant. At standard operating conditions and with a condensing refrigerant temperature of 80°F, the purge discharge shall be better than one pound of noncondensable per pound of refrigerant. The purge system shall include a purge compressor, controls, sight glass oil level indicator, electrically heated oil separator, sectionlized drum permitting separation of noncondensable gases and water from the discharge of the compressor purge, a means of return refrigerant to the condenser and drawing off of noncondensables and solenoid valves to automatically isolate the purge system from the refrigerant circuit when the purge compressor is not in operation. A purge pressure gauge, a number of starts counter, and an hour meter shall be included on the purge system.

G. Pumpout Unit: An automatic pumpout unit and storage vessel shall be factory installed on all high pressure refrigerant (R-22, R-114, R134A, R-500, R-501, etc.) units or the unit shall be capable of storing and isolating the entire refrigerant charge in the unit condenser vessel. Unit shall be factory-installed and piped and shall be furnished prewired with all necessary controls, transfer pump, condensing unit and tank constructed in accordance with ASME Code for unfired pressure vessels bearing the National Board stamp. Pumpout systems shall be supplied and warranted by the centrifugal machine manufacturer. Pumpouts shall comply with the following:

1. Pumpout tank(s) with ASME stamp capable of holding refrigerant charge when 80% full at 90°F.
2. Separate charging connections for liquid and gas refrigerant.
3. Piping and valves between pumpout and chiller to be supplied and installed by installing contractor. Contractor shall provide all piping, electrical equipment, and wiring required. Refrigerant piping shall be Type K hard-drawn copper with wrought copper fittings. Valves shall be packless type suitable for refrigerant use.

H. Recycle/Recovery Unit: The manufacturer shall provide a portable Recycle/Recovery System. The system shall be modular allowing a single operator to transport, unload and install the system without requiring hoists, cranes, etc. the system shall include modular storage tanks, portable evacuation pump, heater, pump high pressure control, water cooled condenser, and pump starter. The system shall be compatible with **[R-123] [R-134a] [ ]** and shall have a storage capacity of **[1000]** lbs. The system shall include 25 ft. of self sealing refrigerant hoses.

I. [Heat Recovery Bundle: Provide a separate heat recovery tube bundle integral to the unit condenser, where scheduled.]

2.4 ACCESSORIES:

A. [Vibration Isolation: Vibration isolation shall be provided at all supports points. Refer to Section 23 05 48, "Vibration Isolation", for requirements.]

B. Refrigerant and Oil Charge: All chillers shall be provided with a full charge of refrigerant and oil. Refrigerant and oil charge shall be checked prior to startup. All or any part of the refrigerant or oil that may be lost during startup or the warranty period, shall be replaced by the chiller manufacturer at no additional cost to the Owner.

C. Thermometer Wells and Site Glasses: Thermometer wells shall be provided to measure liquid refrigerant condensing and evaporating temperature and for all safety controls. Site glasses shall be provided for monitoring refrigerant and oil charge level, compressor rotation and the purge condenser drum.

[SELECT ONE OF THE FOLLOWING]

D. [Differential Pressure Sensors: Provide Orange Research, Inc. or approved equal differential pressure sensors with pressure switches and direct reading differential pressure gauges factory-installed to read across each heat exchanger. Differential pressure gauges shall be factory-mounted in the face of the chiller control panel and the pressure switches shall be factory-interlocked with the chiller controls to provide heat exchanger water flow verification. Sensors shall be similar to Series 1516 with 3-1/2" gauge readout, two reed switches and 316 stainless steel construction. Gauge range shall be adequate to monitor pressure drop from clean tubes to 0.0001 fouled tubes plus a 25% safety margin. Gauges shall be calibrated with water and shall be liquid filled to prevent pointer pulsation.]

[OR]

E. [Flow Switches: Chillers shall have McDonnell-Miller No. FVS-7 or approved equal flow switches factory-installed and wired to provide chilled and condenser water flow verification.]

F. Insulation: All low temperature surfaces including, but not limited to, evaporator and water boxes, suction elbow, economizer and motor cooling piping, shall be factory-insulated with 3/4" closed-cell foam or an approved equal sheet insulation.

G. Painting: All exposed surfaces and insulation shall be primed and painted using the manufacturer's standard paint system and colors.

H. Refrigerant Leak Detection System:

1. Follow minimum standards for Class One refrigeration systems as required by ASHRAE Standard 15-1989, with special attention to Sections 10.13-10/14 dealing with equipment room ventilation and air monitoring.
2. Install an air monitor calibrated to detect concentrations of the refrigerant utilized in ppm.
3. Install suitable local alarms and alarm contacts that activate well below the Threshold Limit Value (TLV) of the refrigerant and alert persons inside and outside of the equipment room that a leak condition exists.
4. Provide N.C. contacts to monitor the leak detection system alarm condition by the Building Control and Automation System (BCAS). In the alarm mode, two (2) additional N.C. contacts shall be provided to start the mechanical room purge ventilation system.
5. The manufacturer shall interface the leak detection system with the chilled controllers to shutdown the chillers in the alarm mode.

2.5 CONTROLS:

A. General: The chiller(s) shall be controlled by a stand-alone Direct Digital Control (DDC) System. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.

B. Control Panel: The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches.

C. Safeties: The chiller control panel shall monitor such safeties as motor starting and running current, motor winding temperature (hermetic motors only), time between compressor/motor starts, low chilled water temperature, high condenser refrigerant pressure, low evaporator refrigerant pressure, high discharge pressure, evaporator and condenser water flows, low oil flow/pressure, and proper operation of unit controls and sensors.

D. Gauges: The chiller control panel is to be provided with the following system pressure information:

1. Evaporator refrigerant pressure.
2. Condenser refrigerant pressure.
3. Oil pressure.
4. Purge drum pressure.

E. Meters: The chiller control panel is to be provided with a starts counter and running time meter.

F. Indicator/Displays: The front of the chiller control panel shall be capable of displaying the following:

1. Entering and leaving evaporator water temperature.
2. Entering and leaving condenser water temperature.
3. Chilled water setpoint.
4. Electrical current limit set point.
5. Chiller operating mode.
6. Chiller diagnostic codes and operating messages.

G. Protection: The chiller control panel shall provide evaporator freeze protection and low limit control. This control shall be used to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature. A diagnostic code/message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.

H. Control Interface Outputs: The chiller control panel shall provide a relay output to start the condenser water pump and/or enable the cooling tower temperature controls.

I. Alarm Outputs: The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

J. Condenser Limit Control: The chiller control panel shall provide condenser limit control to include a pressure transducer and interconnecting piping and wiring. This control shall be used to avoid high condenser refrigerant pressure trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and actual value of the condenser refrigerant pressure. A diagnostic code/message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control mode is in effect.

K. Low Temperature Startup: Include necessary controls to allow the water chilling unit to start with a condenser water temperature of 45°F (7.2°C) and operate continuously at 65°F (18.3°C) condenser water temperature. Single stage units or 2-stage units with inlet vanes in front of only one stage of compression, may utilize automatic hot gas bypass to allow operation at reduced load.

L. [Chilled Water Temperature Reset: The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature or ambient temperature.]

[OR]

M. [Chilled Water Temperature Reset: The unit control panel shall provide leaving chilled water temperature reset based upon a pulse width modulated (PWM), [SCR controlled solid state or] 4-20ma or 0-10 VOLTS DIRECT CURRENT signal from a building automation system.]

2.6 600 VOLT STARTERS:

A. General: Each chiller motor shall be provided with a **[unit mounted] [free-standing] [SCR controlled solid state or] [star delta closed transition]** starter. Motor starter shall have NEMA 1A gasketed enclosure. **[Unit mounted starters shall be fully wired and tested such that only external power and control wiring connections are required in the field.]** Enclosure shall be constructed of 12 gauge steel minimum with the exception of doors which shall be code gauge steel minimum. **[Unit mounted enclosures shall have ventilating louvers or water cooled heat sinks.]** Each door or enclosure more than 48" high shall have three point vault type latches with padlockable handles and gasketing.

B. Connections: Motor starters shall include incoming line provisions for the number and size copper cables shown on the Drawings. Incoming line lugs shall be copper **[mechanical] [compression]** type. Connection directly to the contactors is not permissible.

C. Contactors: Star delta starter contactors shall be sized properly, per the NEMA requirements, to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall have low resistance palladium silver contacts.

D. Control Accessories: Each motor starter shall include a control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.

E. Starter Wiring: Power wiring within the starter shall be Type MTW copper stranded 90°C. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be Type MTW copper stranded 90°C, 14 gauge minimum.

F. Motor Protection: Starter shall include motor protection system incorporating electronic three phase overloads and current transformers. The electronic motor protection system shall monitor and protect against the following conditions:

1. Three phase overload protection.
2. Overload protection during start-up.
3. Phase imbalance.

4. Phase loss.
5. Phase reversal.
6. Low voltage.
7. Distribution fault protection consisting of 3-phase, current sensing devices that monitor the status of the current. Distribution faults of 1-1/2 electrical cycle durations shall be detected and the compressor motor shall be disconnected within six electrical cycles.
8. A lockout transition safety circuit shall be provided to prevent damage from prolonged energization due to malfunction of the transition contractor. Malfunction shall cause the machine to be shutdown and the "starter circuit fault" indicator to be displayed. The overload system shall be coordination with the current control system to provide fail-safe circuitry. A single adjustment shall be used to set all three overloads.
9. **[The motor protection system can, at the manufacturer's option, be furnished as part of the chiller control panel.]**

G. Ambient Temperature: The starter shall be able to operate in temperatures up to 120°F.

H. Additional Features: The following starter features shall be provided:

[EDIT TO SUIT PROJECT]

1. **[Circuit Breaker: Starter shall contain a circuit breaker with an interrupting capacity of [_____] RMS symmetrical amperes. Operating handle and trip indicator shall be located in the door. This handle shall be capable of being padlocked.]**

[OR]

2. **[Disconnect: A nonfused disconnect switch shall be provided.]**
3. Ammeters and Voltmeters: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated. Three voltmeters shall be provided, each reading a phase-to-phase voltage.
4. UL Approval: Starters shall be Underwriters' Laboratories, Inc. approved.
5. **[Capacitors: Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5% at full load conditions (free standing starters only).]**

PART 3 - GENERAL

3.1 INSTALLATION:

A. General: Install chillers, including components and controls required for chiller operation, in accordance with chiller manufacturer's instructions.

B. Location: Locate chiller in general position indicated in relation to other work. Position chiller with sufficient clearance for normal service and maintenance, including clearance for cleaning and replacement of tubes and motor.

C. Components: Install auxiliary piping, solenoid valves, shutoff valves, water strainers and controls for accessory systems, including but not limited to, oil cooler, compressor motor cooler, and purge and transfer system. Comply with manufacturer's instructions.

D. Interlock: Interlock flow switches with chiller controls in accordance with the manufacturer's instructions, except as otherwise indicated.

E. Supervision: The unit manufacturer shall supervise the installation and final checkout of the electrical interlock control wiring and review the location of the flow switches so that they perform the safety function without faulty operation or excessive vibration of the sensor.

F. Finish: Paint damaged and abraded factory finish with touch-up paint matching factory finish.

3.2 RELATED WORK:

A. General: Provide work related to and connected to chiller work and required for a complete chiller installation, including, but not limited to:

1. Piping connections including provisions for disconnecting and servicing of chiller and cleaning/ replacing of tubes.

2. Relief pipe from chiller relief opening to the outside, including a dirt trap and flexible connection. Size relief piping as recommended by the manufacturer.
3. Tapping in condenser lines for acid cleaning.
4. Isolation of chilled water and condenser water piping connections to chiller.
5. Balancing valves in water piping for balancing system operations.
6. Pipe strainers to protect chiller components and controls including pumps, automatic modulating valves, and pneumatic controls.
7. Pipe support and bracing, adequately separated from chiller work in a manner preventing transfer of pipe stresses to chiller components.
8. Flow switches or pressure differential switches, properly installed in a horizontal run of the chilled water piping and condenser water piping near the chiller.
9. Connecting all miscellaneous piping including oil cooler and auxiliary water piping.
10. Vibration and noise isolation as specified in Section 23 05 48.
11. Ambient room conditions, including additional cooling, if required, for open drive motors.
12. Wiring of flow switches or pressure differential switches for chiller interlock.
13. Pressure gauges and thermometers as specified in Section 23 20 10, "HVAC Piping Valves and Accessories".
14. Electrical wiring by Division 26 to compressor motor controller with interconnecting wiring to chiller control panel and unit motors, as required.
15. Electrical wiring by Division 26 to oil pump/starter, refrigeration transfer compressor/starter and controls, if required.
16. The unit control circuit shall be arranged so that on start up, the chilled water pump, condenser water pump and oil pump shall start first and the compressor motor shall start after operation conditions have been satisfied. On shutdown, the compressor motor shall stop first and the chilled water pump, condenser water pump and oil pump shall stop after a suitable time-delay period.

B. Prestart-up: Complete the preparation and review the report on related work prior to chiller start up; do not start chiller until inadequacies have been corrected in a manner acceptable to the chiller Installer.

3.3 START-UP SERVICES:

A. Manufacturer Supervision: A factory-trained technical service representative of the manufacturer shall supervise the field-assembly (if any), installation and startup of each chiller, for a minimum of five working days, plus one additional day for each chiller unit in excess of one unit. Prepare manufacturer's written report/log of the installation and startup, signed by the service representative and the Owner.

1. Representative shall supervise leak testing, evacuation, dehydration, vacuum pumping, charging, lubrication, including the filling of reservoirs and confirm that lubricant is of the quantity and type as instructed by the manufacturer.
2. Representative shall instruct the Owner's operating personnel in the operation and service of the units for a period of one week, based on a 40 hour week, excluding nights, weekends, and travel time to and from the Project.

B. Sustained Operation: Do not place chiller in sustained operation prior to initial balancing of the mechanical systems affected by chiller operation. Refer to requirements of Section 15020, "Operational Test-Adjust-Balance".

C. Cooperation: Cooperate with other trades and installers of other work during the testing, adjusting, balancing, and start up of mechanical systems.

3.4 TESTING:

A. General: Except as otherwise indicated, test chiller in accordance with ARI Standard 550-90.

B. Pressure Test: Conduct a standing pressure test on the refrigerant circuit for a period of 12 hours using nitrogen without exceeding test pressure recommended by the manufacturer. Conduct a standing vacuum test on the vessel equal to 1 mm Hg absolute for a 24 hour period. Refrigerant shall

be charged, through filter dryers, to a recommended level. Machine shipped precharged need not comply with this requirement unless the factory precharge or holding charge is lost during shipment or prior to start up, in which case the Contractor shall test as indicated. Perform all tests and start up in such a manner as not to introduce moisture into the machine. Flush system as required to remove non condensables.

C. Oil Samples: Obtain oil samples from each compressor at start up, label and send one sample in a clean, clear, suitable container with screw cap to the Engineer's office**. [Send one sample in a suitable container to Analysts Services, Inc., 12715 Royal Drive, Stafford, Texas.]** This sample will provide a base reference for all samples taken during the warranty period. At the end of the next two 30 day periods, samples as above shall be taken and distributed. If no recommendations are made by the Engineer or Analysts Services, Inc., samples shall then be taken at 60 day intervals and distributed as above. This testing program shall provide a minimum of eight samples of two each during the warranty period. Test shall include Karl Fisher Titration Test. If a problem is indicated at any time during this process, the Contractor shall take whatever steps necessary to ascertain the cause of any oil contamination. Any remedial measures shall be done at no expense to the Owner. The Contractor may at any time submit additional samples to the compressor manufacturer for analysis and a factory-recommended procedure to be followed. All remedial measures shall be reviewed by the Engineer before beginning any work.

D. [Annual Service: At the end of the one year warranty period, the chiller manufacturers service organization shall provide all labor, materials and equipment for an annual chiller service including, but not limited to: removing heat exchanger heads and inspecting/cleaning tubes, oil change/analysis, motor servicing and other manufacturer recommended service. This service shall be performed at no cost to the Owner.]

END OF SECTION 23 64 16