

PART 1 GENERAL**1.1 RELATED DOCUMENTS**

- A. The requirements of the General Conditions, Supplementary Conditions and the following Specification sections apply to all Work herein:
1. Section 23 00 10 - General Requirements
 2. Section 23 00 20 - HVAC Scope of Work
 3. Section 23 05 07 - Design Conditions
 4. Section 23 05 13 - Motor Requirements for HVAC Equipment
 5. Section 23 05 30 - Miscellaneous Equipment
 6. Section 23 05 48 - Vibration Isolation
 7. Section 23 05 93 - Testing, Balancing, and Adjusting
 8. Section 23 07 00 - Thermal Insulation
 9. Section 23 21 13 - Pipes, Valves, Fittings, and Accessories
 10. Section 23 21 23 - Pumps
 11. Section 23 25 00 - Water Treatment Systems
 12. Section 23 41 00 - Tanks and Vessels
 13. Section 23 65 13 - Factory Assembled Cooling Towers

1.2 SUMMARY

- A. Furnish and install centrifugal water chilling units as herein specified and as indicated on the Drawings.

1.3 REFERENCE STANDARDS

- A. All centrifugal water chilling units and accessories shall be designed, manufactured and tested in accordance with the latest applicable industry standards including the following:
1. ANSI B9.1
 2. AHRI Standard 575-2008
 3. AHRI Standard 550/590-2003
 4. AHRI Standard 580-2009
 5. ASTM C177
 6. ASTM E96
 7. ASHRAE 1990R
 8. NEMA Standard ICS 2 Industrial Control Devices, Controllers and Assemblies Standards
 9. ASME
 10. UL Standard 508
 11. ASHRAE Guideline 3-1996
 12. ASHRAE Standard 147-2002
- B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the authorities having jurisdiction, and suitable for its intended use on this Project.

1.4 SUBMITTALS AND PROPOSALS

- A. The following submittal data shall be furnished according to the General Conditions and Section 23 00 10 and shall include, but not be limited to:
1. Water Chilling Unit* complete with physical dimensions, materials, capacity data, water pressure drops, foundation requirements, vibration isolation, controls, connection details, oil pump motor controller, electrical characteristics, Specification Compliance Review report as described in Section 23 00 20, etc.
 2. The water chilling unit manufacturer shall include a specification compliance review report as described in Section 23 00 20 with the Subcontractors bid proposal. The compliance review will be a paragraph-by-paragraph review of the specifications with the following designations "C", "D" or "N/A" marked in the right hand margin beside each paragraph. The Subcontractor shall submit with his bid proposal three copies of data brochures from each water chilling unit manufacturer for the Engineer's and Owner's evaluations.

3. Prior to execution of factory testing and field testing, submit test procedures, recording forms, and test equipment cut sheets to Engineer for review. Refer to Section 23 00 20 titled "Scope of Work" for "Scheduling Procedures".
 4. Factory Test Schedule.
 5. Factory Refrigerant Side Proof Testing Report.
 6. Factory Eddy Current Test Report.
 7. Factory Compressor Vibration Test Report for all units.
 8. Factory Compressor Vibration Test Report for all units if Alternate (M-11A to C) is accepted.
 9. Factory Witnessed Performance and Sound Test Report if Alternate (M-12A to C) is accepted.
 10. Field Test Schedule.
 11. Field Test Reports.
 12. Field Eddy Current Test Report if Alternate (M-14) is accepted.
 13. Oil Filter Replacement after first 100 hours of operation.
 14. Refrigerant Filter/Dryer if Alternate (M-10A to C) is accepted, provide a complete piping diagram for review.
 15. Terminal Block interlock control wiring diagrams.
 16. Centrifugal Compressor Motor Controller* complete with physical dimensions, materials, electrical characteristics, fault current withstand ratings, connection details, Specification Compliance Review report as described in Section 23 00 20, etc.
 17. Variable Speed Drives* complete with physical dimensions, materials, electrical characteristics, fault current withstand ratings, connection details, Specification Compliance Review report as described in Section 23 00 20, etc.
 18. Factory Specialist Training.
 19. Machine Leveling Report documenting all field measurements and corrective action at each water chilling unit location.
 20. Maintenance Agreement for the warranty period if Alternate (M-15A to C) is accepted.
- B. Training Schedule including extent of scope and estimated time duration.
- C. All items or equipment listed above with asterisks (*) shall be certified by the manufacturer using Manufacturer Certification "MCA" as set forth in Section 23 00 10. See Section 23 00 10 for certification requirements.

1.5 WARRANTY

- A. Comply with the requirements of the General Conditions and Section 23 00 10.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. If it complies with these Specifications, centrifugal water chilling units manufactured by one of the following manufacturers will be acceptable:
1. Carrier
 2. Trane
 3. York
- B. If it complies with these Specifications, water chilling unit controllers manufactured by one of the following manufacturers will be acceptable:
1. Allen-Bradley
 2. Carrier
 3. Cutler Hammer
 4. General Electric
 5. Siemens
 6. Trane
 7. York

- C. If it complies with these Specifications, refrigerant recycle, reclaim and transfer equipment manufactured by one of the following manufacturers will be acceptable:
1. Carrier
 2. NEVA
 3. Trane
 4. York

2.2 GENERAL

- A. Each water chilling unit shall be of the accessible hermetically sealed centrifugal type driven by either a gas refrigerant cooled, liquid refrigerant cooled or open air cooled electric motor. Compressor motors shall be of the squirrel cage type suitable for operation at 3600 rpm and with the current and starting characteristics as specified herein or shown in the "Schedule of Capacities" on the Contract Documents.
- B. If a water chilling unit utilizing an open air cooled motor is installed the Subcontractor shall provide a central plant cooling only draw through type air handling unit which conforms to the requirements listed in Section 23 73 13, associated distribution ductwork, chilled water piping, vibration isolation and additional water chilling unit capacity, or the Subcontractor shall increase the capacity of the central plant ventilation system, subject to the review and approval of the Engineer. The Subcontractor shall base the increased capacity and/or equipment selections on the amount of the motor heat of the open air cooled electric motor driven units and all associated cost shall be include in the Subcontractor's bid proposal. The amount of motor heat needed to be relieved and the additional chilling unit cooling capacity required to be provided by the Subcontractor shall be calculated as follows:

$$\text{Capacity of AHU and Chilling Unit Tonnage Increase} = (\text{FL Motor kW}) \times (0.045) \times 0.2845 \text{ Tons}$$

$$\text{CFM Increase of the Cooling AHU System} = \frac{(\text{FL Motor kW}) \times (0.045) \times (3413) \text{ CFM}}{(104-95) \times (1.085)}$$

- C. Each unit shall be furnished complete with compressor, condenser, evaporator, refrigerant monitor, purge unit with low pressure relief vent for HCFC-123 machines, reseatable relief valves and vent piping for HFC-134A machines, motor controller, microprocessor based control panel and vibration isolators. The evaporators and the condensers shall have flanged, welded, or cut grooved pipe connections and shall be piped as indicated on the Drawings.
- D. All water chilling units of a given capacity shall be identical in design and construction. All the water chilling units shall have the capacities listed in the "Schedule of Capacities" on the Contract Documents. Each unit shall be capable of producing the scheduled leaving chilled water temperature at design conditions with an evaporator fouling factor of 0.0001 and a condenser fouling factor of 0.00025.
- E. Refrigerant HCFC-123 or HFC-134A may be used if all capacity and operating conditions specified are strictly observed in every detail. Provide refrigerant isolation valves and service fittings on the evaporator for a remote separate transfer (pump out) system as specified herein.
- F. To minimize compressor motor requirements, any unit having a multistage compression cycle shall incorporate an economizer refrigerant cycle.
- G. Water chilling units utilizing HFC-134A refrigerant shall be provided with a discharge line sound reduction kit. Water chilling units utilizing HFC-134A refrigerant shall be provided with refrigerant isolation valves on both sides of the condenser to allow storage of the complete refrigerant charge in the condenser.

2.3 CENTRIFUGAL WATER CHILLING UNITS

- A. Each compressor shall be of the hermetic or open motor driven centrifugal type. The operating speed shall be below the first critical speed of the shaft assembly. The shaft seal for open drive compressors shall be designed to limit refrigerant loss to 1.0 pounds per year. If the design loss is higher than this, provide a refrigerant reclaim system to limit the loss to 1.0 pounds per year. The horizontal or vertical vibration shall not exceed 1.0 mil at any bearing.

- B. The evaporator and condenser units shall be of the shell-and-tube type designed in accordance with requirements of the latest edition of the ASME Code for unfired pressure vessels. The refrigerant side shall be proof tested at a pressure 1.3 times greater than the maximum design working pressure for positive pressure (HFC-134a) machines and 1.25 times greater than the maximum design working pressure for negative pressure machines (HCFC-123). Working pressure shall be equivalent to a saturated pressure temperature of at least 113°F.
- C. Refrigerant relief valves shall be provided for the refrigerant circuit. Refrigerant relief valves shall be connected to the relief piping with flexible stainless steel hoses and quick connects as detailed on the Drawings. Refrigerant relief valves for low pressure (HCFC-123) machines shall have a "rupture guard" metal bursting disc and spring actuated reseatable relief valve system to prevent refrigerant loss after the excess pressure is reduced. Refrigerant relief valves for low pressure (HCFC-123) machines with a carbon rupture disc will not be acceptable. Refrigerant relief valves for positive pressure (HFC-134A) machines shall have a spring actuated reseatable system to prevent refrigerant loss after the excess pressure is reduced.
- D. Condenser and evaporator tubes may have externally and internally enhanced tubes for improved heat transfer. Internal enhancement of the tubes shall be a rifling type design. Integral finned enhanced tubes in both the evaporator and condenser shall have plain smooth lands at all intermediate tube supports to provide maximum tube wall thickness at the tube support area or equipped with spring type tube clips for support between the tubes and the tube sheets. Evaporator tube wall thickness root to root at the fin shall be at least 0.025". Condenser wall thickness root to root at the fin shall be at least 0.025". If the evaporator and condenser tubes cannot be provided with smooth lands at the tube supports or spring type tube clips, fully enhanced tubes shall have a 0.035" wall thickness at the root fin. Tubes shall be individually replaceable with tube ends rolled into annular single or double grooves in the tube sheets or rolled into the tube sheet using "Loctite" to achieve the refrigerant seal. All condenser and evaporator tubes shall be eddy current tested in the field after flushing and cleaning of piping systems and prior to startup by an independent agency acceptable to the Owner. The Subcontractor shall provide all materials and labor required for these tests. Test report and logs shall be submitted to the Engineer and Owner. Taps for vents and drains shall be provided.
- E. The minimum allowable refrigerant temperature at design conditions shall be as shown in the "Schedule of Capacities" on the Contract Documents. The water spaces shall be suitable for the working pressure listed in the "Schedule of Capacities" on the Contract Documents according to the latest edition of ANSI B9.1.
- F. Each unit shall be provided with a capacity control system consisting of automatically controlled variable inlet vanes at the entrance of the impeller. The vanes shall be controlled to provide continuously variable capacity from fifteen (15%) percent to one hundred (100%) percent output with a minimum condenser water temperature of 65°F. The capacity control system shall be arranged to stop the water chilling unit whenever the loads fall below fifteen percent (15%). When the water chilling unit is stopped by the low load recycle system, continuous trips or safety trips the water chilling unit shall be prevented from restarting until after the motor winding temperature drops to acceptable levels as determined by the water chilling unit manufacturer and the machine can be safely restarted at least a fifteen (15) minute time delay from the last start. Inlet guide vanes shall be closed for unit restart.
- G. A positive displacement oil pump shall provide lubrication to all parts requiring oil. The oil pump shall be suitable for operation on the current characteristics as shown on the Drawings or in the "Schedule of Capacities" on the Contract Documents. Provide factory installed isolation valves for the replaceable oil filters to permit filter changes without removal of the refrigerant charge.
- H. The initial refrigerant and oil charges shall be furnished and installed by the water chilling unit manufacturer in sufficient quantities to fully charge the system and to leave it in complete and satisfactory operating condition. All or any part of the refrigerant or oil charge that may be lost during the factory operations shall be replaced by the water chilling unit manufacturer. All or any part of the refrigerant or oil charge that may be lost during the period of the Project warranty shall be replaced by the Subcontractor under this Section of the Specifications without additional cost to the Owner.
- I. The initial oil filter shall be replaced by the Subcontractor after a maximum 100 hours of operation or less if recommended by the water chilling unit manufacturer.

- J. The water chilling unit manufacturer shall provide an add alternate (M-10A to C) for factory installation of a refrigerant filter drier contaminant removable system as specified herein. The refrigerant circuit on negative (HCFC-123) and high (HFC-134a) pressure machines shall be complete with a factory installed refrigerant filter drier contaminant removal system complete with replaceable core filter dryers, Penberthy jet pump, two (2) moisture/sight glass indicators, valves and associated piping. The refrigerant piping circulation system shall be configured as indicated in Figure 4 of Sporlan Valve Bulletin 240-10-3, (excluding manual vent). The Subcontractor shall submit a complete piping diagram with piping sizes indicated to the Engineer for review. All refrigerant valves shall be Superior, Henry, Primore, Muller or approved equal refrigerant quality valves suitable for use with HCFC-123 and HFC-134a refrigerants.
- K. The water chilling unit manufacturer shall submit a test report of the factory compressor vibration analysis test to the Engineer and Owner. The water chilling unit manufacturer shall provide an add alternate (M-11A to C) for a field vibration analysis on each water chilling unit. The vibration analysis testing shall be performed at fifty (50%) percent, seventy-five (75%) percent and one hundred (100%) percent load conditions by an independent agency acceptable to the Owner.
- L. All low pressure water chilling units using HCFC-123 refrigerant shall be provided with a factory installed high efficiency purge system, which shall operate in a manual (ON/OFF) mode or automatically as required to continuously remove condensables whenever the water chilling unit is running or while the water chilling unit is idle. The purge system shall be as recommended by ASHRAE Guideline 3-1996. Purge system shall have an AHRI Standard 580 purge efficiency to lose not more than 0.01 pounds of refrigerant per pound of air discharged or a certified purge efficiency of 0.76 pounds of refrigerant per pound of air.
- M. The water chilling unit manufacturer shall factory install refrigerant isolation valves or wells in each sensor device, which is not integral to the water chilling unit as required to isolate the sensor for maintenance.
- N. Control and instrumentation shall be as follows:
1. Provide a programmable microprocessor based unit control panel for each water chilling unit. The unit control panel shall monitor and control the entire unit operation including all sensors, actuators, relays and switches for refrigeration, electric and electronic controls. The microprocessor shall be provided with factory installed battery backup or utilize a non-volatile memory (EE Prom). The entire control system shall be factory assembled and tested. Refer to Division 25 for coordination and Building Management and Control System (BMCS) interface.
 - a. Operating Controls:
 - 1) Leaving chilled water temperature - maintain a leaving water temperature within $\pm 0.5^{\circ}\text{F}$ (0.3°C) of setpoint for water flow varying from sixty to one hundred and twenty (60 - 120%) percent of design flow and for load conditions from ten to one hundred (10 - 100%) percent. Setpoint shall be adjustable from the System Control Panel and from the BMCS supplied under Division 25.
 - 2) Motor current limit control. Demand limit setpoints shall be adjustable from the BMCS supplied under Division 25.
 - 3) Recycle control to prevent restarting within fifteen (15) minutes from the last start or a motor protection system to prevent restarting based on motor winding temperature.
 - b. Safety Controls:
 - 1) Low evaporator temperature.
 - 2) Condenser high pressure.
 - 3) Oil temperature.
 - 4) Motor starting and running.
 - 5) Evaporator and condenser water flows.
 - 6) Proper operation of unit controls and input elements.
 - 7) Motor current protection, including starting and running, for phase unbalance, phase reversal, phase loss or electrical distribution fault.
 - 8) Chilled and condenser water differential pressure switch sensors shall be furnished under Division 25.
 - 9) All safety controls shall require a manual reset, which prevents restarting until the safety condition is corrected.
 - c. Status and Diagnostic Monitoring:
 - 1) Complete status of unit.
 - 2) Status indicating lights or status display.
 - 3) Setpoint and water temperature display.
 - 4) Start counter and running hours.

- 5) Refrigerant temperature.
- 6) Provide a coded or alphanumeric coded display for all diagnostic monitoring.
- 7) Common alarm relay package to transmit an alarm to the Division 25 Control System.
- d. Interface to the Division 25 BMCS:
 - 1) Provide a BacNet, software communication interface between the Division 25 BMCS and the chiller controller units. The digital communications interface shall be set up so as to provide, at minimum, the following monitoring and control points:
 - a) Entering Chilled Water Temperature (monitoring point).
 - b) Leaving Chilled Water Temperature (monitoring point).
 - c) Evaporator Pressure (monitoring point).
 - d) Auxiliary Oil Pressure (monitoring point).
 - e) Bearing Pressure (monitoring point).
 - f) Evaporator Differential Pressure (monitoring point).
 - g) Evaporator Temperature (monitoring point).
 - h) Suction Temperature (monitoring point).
 - i) Pre-alarm (monitoring point).
 - j) Oil Compressor Status (monitoring point).
 - k) Flow Safety (monitoring point).
 - l) Motor Safety (monitoring point).
 - m) Motor Run (monitoring point).
 - n) Current Limit (Control point).
 - o) Chilled Water Supply Temperature Reset (Control point).
 - p) Chilled Water Pump Status (monitoring point).
 - q) Entering Condenser Water Temperature (monitoring point).
 - r) Leaving Condenser Water Temperature (monitoring point).
 - s) Up to twenty operator defined points.
 - 2) Provide interfaces with the Division 25 BMCS as follows:
 - a) Start/stop: 24 DC contact.
 - b) Status: 24 DC contact.
 - c) General alarm: 24 DC contact.
2. If it is required for interface, provide a communication gateway. The gateway shall be connected to each unit control panel and shall provide the interface to the Building Management and Control System supplied under Division 25.
3. Interlock wiring and control requirements are as follows:
 - a. Submit complete terminal block to terminal block interlock control wiring diagrams for the refrigeration machinery and its associated equipment such as the chilled water pump, condenser water pump, time delay relays, water flow and differential pressure switches, refrigeration safety controls, emergency shutdown, etc.
 - b. All interlock control diagrams shall be prepared by the water chilling unit manufacturer in arrangements as required to provide the sequence of system operation specified in this Section and in the Division 25 Specifications. Provide terminal points for the "Emergency Shutdown Switch", as detailed on the Electrical Drawings and the refrigerant monitoring system alarm shutdown as specified in Section 23 05 30 titled "Miscellaneous Equipment". If a sequence or time delay change is required by the water chilling unit manufacturer, the changes shall be submitted to the Engineer prior to submission of Shop Drawings.
 - c. All coordination necessary for obtaining proper composite Drawings shall be provided by the Subcontractor. The services of the water chilling unit manufacturer shall be employed to supervise the installation and final checkout of the electrical interlock control wiring.
 - d. The Division 25 Subcontractor shall furnish and the Division 23 Subcontractor shall install differential pressure switches in the chilled water piping to each water chilling unit and in the condenser water piping to each condenser. The purpose of the switches is to stop the compressor in case of a water failure or low flow. The switches shall be set to stop the compressor at a tube velocity not less than 3' per second. The water chilling unit manufacturer shall provide the differential pressure setting corresponding to this velocity to the Division 23 Subcontractor. The Division 23 Subcontractor shall take extreme care in locating the switches so that they perform the safety function without faulty operation or excessive vibration of the sensor. The locations of the switches shall be subject to the approval of the water chilling unit manufacturer and to the review by the Engineer. At the Subcontractor's option factory mounted, piped and wired differential pressure transducers for the cooler and condenser for proof of water flow, safety trip settings, pressure differential indications for flow balancing may be provided and installed by the water chilling unit manufacturer.

- e. The water chilling unit manufacturer shall provide a pilot relay factory wired to a numbered terminal strip or acceptable hand wired interlocks which shall be used for the chilled water pump safeties. This relay contact or interlocks shall prevent stopping of the chilled water pump by any automatic means or by the "OFF" position of the chilled water pump motor controller "H-O-A" switch whenever the water chilling unit motor is in the run winding.
 - f. Each water chilling unit shall be electrically interlocked with its respective chilled water and condenser water pump via auxiliary contacts in the pump starters to prevent operation of the water chilling unit if either pump is not operating. Coordinate interlock wiring requirements with the Division 26 Subcontractor.
 - g. All equipment required for safe operation of this equipment, but not specifically noted to be furnished in Division 25 shall be furnished by the water chilling unit manufacturer.
- O. The water chilling unit manufacturer shall furnish the services of a factory trained specialist to supervise the unit assembly, pressure testing, evacuation, the checkout of the interlock wiring and the startup of the units. The water chilling unit manufacturer shall certify in writing that this Work was supervised and approved. In addition, the factory trained specialist shall also instruct the Owner's operating personnel in the operation and service of the units for a period of eight (8) hours, excluding nights, weekends and travel time to and from the Project. See Section 23 00 10 for warranty and additional requirements.
- P. The water chilling units shall provide the minimum capacities specified under the specified operating conditions based on the capacity determination procedure set forth in AHRI Standard 550/590-2003 and within the allowable efficiency and capacity tolerances set forth herein (Paragraph 3.02, Factory Testing).
- Q. In accepting this Contract, the water chilling unit manufacturer shall guarantee their water chilling units to give capacities not less than the capacities specified with the conditions as specified and will take whatever steps are necessary to meet the guarantee, at no additional cost to the Owner, regardless of the extent of the revisions required. A Corporate Officer of the manufacturer shall certify the guarantee and the submittal data as specified in Section 23 00 10.
- R. The maximum permissible noise levels under design operating conditions, when measured in accordance with AHRI 575-2008 specified methods and qualifications, shall not exceed 90 dBA.
- S. Water chilling units shall be factory insulated as follows:
- 1. All cold surfaces of the water chilling unit, including the evaporator and suction piping between the evaporator and the first stage compressor, economizer, cold gas connection to gas cooled motor and auxiliary piping at the job site shall be insulated with 3/4" thick Armstrong Armaflex II, Insmont, Rubatex or Uniroyal flexible elastomeric closed cell sheet insulation with 25/50 UL fire rating or approved equal. In the case of an unishell (cooler/condenser in one shell) vessel, the entire vessel, including the condenser section, shall be insulated. Insulation shall have a K factor not exceeding 0.28 at 75°F mean temperature when tested by ASTM C177 and a water vapor permeability of 0.17 perm-inch or less when tested by ASTM E96, Procedure B Method.
 - 2. Insulation shall be applied to the surface to be insulated with an adhesive suitable for the insulation used over the entire surface unless insulation has an adhesive backing. The butt joints shall be sealed with adhesive. The entire insulation installation shall be in accordance with the manufacturer's recommended installation instructions.
 - 3. The insulation shall be finished with two (2) coats of vapor seal coating or low transmittance vapor retardant.
 - 4. The Subcontractor shall field insulate evaporator water boxes and any other areas that show evidence of sweating during operation. Field insulation shall be the same as the factory insulation.
- T. Motor terminations and termination enclosure shall be so designed as to accept compression fittings of the proper size (See Division 26, Section 26 05 19 titled "Electrical Conductors – 600 Volts") as well as the conduits and conductors without field modifications of any description. No wiring connection regardless of wire size shall be made by means of any type of mechanical set screw or bolt type lug.

2.4 VARIABLE SPEED DRIVES

- A. For each centrifugal water chilling unit compressor motor, furnish a unit mounted factory installed variable speed drive, where scheduled on the drawings.

- B. Drives shall be pulse width modulated (PWM) type utilizing insulated gate bipolar transistors (IGBT's) with a minimum power factor of 0.95 at all loads and speeds. The variable speed drive shall be provided with the proper harmonic filter technology to limit the current output total harmonic distortion (THD) to less than 30%. Provide input line reactors or tuned line filters, adjusted as required, to minimize any electrical distortion back into the building electrical power supply system to less than three (3%) percent in accordance with IEEE Standard 519-1992 limits.
- C. Factory witnessed performance tests shall be done with water chilling units in their final configuration. Factory witnessed performance testing shall be done with all required harmonic filters. The chiller manufacturer shall account for all variable speed drive losses in KW and NPLV in the total efficiency values submitted.
- D. Variable speed drives shall be unit mounted in a NEMA-1 enclosure. All power and control wiring shall be factor installed, including power wiring to the chiller oil pump. Field power wiring shall be a single point connection. Water chilling unit shall provide the electrical lugs for the incoming power wiring. The entire water chilling unit package shall be U.L. listed. The variable speed drive withstand rating shall be in accordance with UL Standard 508 and shall be certified by the controller manufacturer in accordance with the requirements in Section 23 00 10. The controller shall be provided with a current limiting circuit breaker mounted in the enclosure as needed to provide a short circuit (fault) current withstand rating sufficient for the available RMS symmetrical amperes shown on the Division 26 Drawings or as indicated in these Specifications.
- E. Variable speed drives shall be furnished with front access only. Back or side access requirements will not be acceptable.
- F. Internal wiring conductors and bus bars shall be copper. Aluminum conductors are not acceptable.
- G. Variable speed drives shall be designed for operation on the voltage and current characteristics as shown on the Drawings or listed in the "Schedule of Capacities" on the Contract Documents.
- H. Variable speed drives shall be refrigerant cooled, chilled water cooled, or condenser water cooled. Heat exchangers on water cooled variable speed drives utilizing condenser water shall be cleanable shell and tube type. Plate type heat exchangers will not be acceptable on condenser water cooled equipment. All interconnecting piping shall be factory installed and insulated, and shall be pressure rated for the same working pressure as required by the cooling source.
- I. The variable speed drives shall include the following features:
1. Variable speed drive and motor protection from the following faults:
 - a. U.L. Listed ground fault protection.
 - b. Over-voltage and under-voltage protection.
 - c. Output line-to-line short circuit protection.
 - d. Line-to-ground short circuit protection.
 - e. Phase loss at input.
 - f. Phase reversal / imbalance.
 - g. Over temperature.
 2. Minimum and maximum speed adjustments.
 3. Surge control.
 4. Adjustable current limiting and UL approved electronic motor overload protection.
 5. All control circuit voltages are physically and electrically isolated from power circuit voltage.
- J. The following variable speed drive status indicators shall be available at the water chilling unit control panel to facilitate startup and maintenance:
1. Output speed in hertz and rpm.
 2. Input line kW/kVA.
 3. 3-phase input line voltage.
 4. 3-phase output current.
 5. Average current in percent RLA.
 6. 3-phase input voltage total harmonic distortion (THD).
 7. 3-phase input current total demand distortion (TDD).
 8. Total power factor (including filter losses).

9. Fault diagnostics (as listed above).
10. Variable speed drive self-diagnostic service parameters.

2.5 OIL PUMP MOTOR CONTROLLERS

- A. For each hermetically sealed oil pump, which is not integral to the water chilling unit, the Contractor shall furnish an automatic across-the-line motor controller suitable for either, 460V, three (3) phase, 60 hertz or 120V, single phase, 60 hertz operation. See Section 23 05 13 titled "Motor Requirements for HVAC Equipment" for motor controller specifications. The separate oil pump controller shall be mounted adjacent to the water chilling unit compressor motor controllers.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Centrifugal water chilling units and accessories shall be installed in accordance with the latest industry standards, per the manufacturer's recommendations and installation manual, and as indicated on the Drawings.
- B. If the water chilling unit factory vacuum or pressure is lost because of leaks, the Subcontractor shall conduct a standing vacuum or a pressure test using nitrogen on the refrigerant circuit for a period of twelve (12) hours using nitrogen. Do not exceed test pressure recommended by the manufacturer. All detected leaks shall be repaired and the test repeated until system is leak proof. The Subcontractor then shall conduct a standing vacuum test on the vessel equal to 1 mm Hg absolute using a vacuum pump, for a twenty-four (24) hour period. All detected leaks shall be repaired and the test repeated until system is leak proof. Refrigerant of the highest quality shall be charged, through filter dryers, to the "at rest" level marked on the refrigerant sight gauge glass. Machines shipped precharged need not comply with this requirement unless the factory precharge or holding charge is lost during shipment or prior to startup, in which case the Subcontractor shall pressure test, vacuum test, repair leaks and charge as specified herein in this paragraph. Oil will be added to the machine and all startup and check out procedures shall be performed in such a manner as not to introduce moisture into the machine.
- C. The Subcontractor shall furnish and install all necessary relief valves, vent piping and flexible connectors, auxiliary water piping for oil coolers, purge and pump out condensers, all piping, valves, fittings and all necessary connections for a complete and workable system in accordance with the water chilling unit manufacturer's recommendations. Refrigerant vent piping shall also be provided and installed in accordance with the local code authorities having jurisdiction. Refrigerant relief vent piping shall be black steel pipe as specified for chilled, condenser and heating hot water piping in Section 23 21 13 titled "Pipe, Valves, Fittings, and Accessories" except it may be Schedule 20 pipe.
- D. The Subcontractor shall install each unit on isolation as specified in Section 23 05 48 titled "Vibration Isolation".
- E. The Subcontractor shall level each machine in accordance with the manufacturer's recommendations. The vibration isolators shall not be used to level the machine. The Subcontractor shall verify in writing to the Engineer that the machine is level based on actual field measurements.

3.2 TRAINING

- A. Instruct designated building operating personnel in proper operation and maintenance of all components of the water chilling unit. Submit a proposed Training Schedule for review by the Engineer including extent of the scope and estimated time duration. See Section 23 00 10 for additional information.

3.3 FACTORY TESTING

- A. The water chilling unit manufacturer shall provide an add alternate (M-12A to C) for a factory witnessed performance test. All centrifugal water chilling units shall be factory tested at full load (100%), seventy-five percent (75%), fifty percent (50%), and twenty-five percent (25%) load to ensure that the water chilling units are in compliance with AHRI Standard 550/590-2003 for capacity and efficiency performance. Factory test

- shall be witnessed by the Owner and Engineer. Water chilling units shall be rated as per AHRI 550/590-2003 and shall produce 100% of the specified capacity (0% AHRI 550/590 tolerance on tons). Allowable power input tolerances shall be the more stringent of the AHRI Standard 550/590-2003 or five (5%) percent at all conditions down to a minimum of twenty-five (25%) percent load. Evaporator and condenser water pressure drop shall not exceed 105% of the specified pressure drop at design conditions.
- B. The centrifugal water chilling units shall be factory tested at full load for sound performance in accordance with AHRI Standard 575-1994.
 - C. For identical water chilling units, only one (1) unit shall be tested, however the compressors on all machines shall be one hundred (100%) percent run tested to ensure proper operation of all compressor systems.
 - D. Certified factory test reports signed by a corporate officer shall be submitted to the Engineer and Owner within two (2) weeks of factory testing. The water chilling unit manufacturer shall use the manufacturer certification "MCA" as set forth in Section 23 00 10. See Section 23 00 10 for certification requirements.
 - E. A representative from the Engineer and/or the Owner's representative may witness factory testing of the equipment at the time of manufacture. The HVAC Subcontractor shall notify the Engineer and Owner in writing at least three (3) weeks prior to the day of the factory test. The HVAC Subcontractor shall have a representative attend the factory test with the Engineer and/or Owner's representative.

3.4 FIELD TESTING

- A. Prior to execution of field testing, submit test procedures, recording forms, and test equipment cut sheets to Engineer for review. Refer to Section 23 00 20 titled "Scope of Work" for "Scheduling Procedures".
- B. The HVAC Subcontractor shall notify the Engineer and Owner in writing at least two (2) weeks prior to the day of the field test. The Engineer and Owner may witness the field test if they so desire.
- C. In addition to the testing described herein, refer to Section 23 05 93 for additional testing requirements for centrifugal water chilling units.
- D. If Alternate M-14 is not accepted, the water chilling unit manufacturer shall furnish the services of a specialist acceptable to the Engineer and Owner trained in eddy current to perform field eddy current testing of all evaporator and condenser tubes for each water chilling unit prior to startup, as specified in paragraph 2.03, B. If Alternate M-14 is accepted, a second set of field eddy current tests for each water chilling unit shall occur at the end of the project warranty period.

3.5 MAINTENANCE AGREEMENT

- A. The water chilling unit manufacturer shall provide an add alternate M-15A to C for a maintenance agreement during the warranty period. A copy of the maintenance agreement shall be provided at bid time to the Owner and Engineer for review.
- B. Services provided shall include the following per year for each year of the maintenance agreement:
 - 1. Operationals – 3 per year
 - a. Check with customer representative for operational deficiencies.
 - b. Check for proper water flow.
 - c. Complete any required maintenance checklists, report observations to appropriate customer representative.
 - d. Clean equipment, control panels, and area around equipment after each service.
 - e. Check refrigerant charge.
 - f. Check all oil levels.
 - g. Check capacity control and linkage.
 - h. Check oil heater.
 - i. Check operation of purge equipment. Review purge minutes vs. run time to determine if leak test is required.
 - j. Visually inspect for refrigerant or oil leaks.
 - k. Check for unusual noise or vibration.

- I. Check overall condition of unit.
2. Comprehensives – 1 per year
 - a. Complete any required maintenance checklists, report observations to appropriate customer representative.
 - b. Clean equipment, control panels, and area around equipment after each service.
 - c. Check overall condition of unit.
 - d. Check for unusual noise or vibration.
 - e. Inspect and tighten all electrical terminals.
 - f. Inspect starter / VSD.
 - g. Meg ohm test compressor motor.
 - h. Conduct refrigerant leak test.
 - i. Conduct visual inspection of condenser tubes.
 - j. Check capacity control and linkage.
 - k. Check safeties.
 - l. Reset purge counter and change purge filter.
 - m. Check oil heater.
 - n. Check all oil levels.
 - o. Replace clean-up kit filter / dryer cores.
 - p. Lubricate motor bearings, check speed increaser, verify drive alignment, check drive coupling, and operating controls (open drive water chilling units).
 - q. Check with customer representative for operational deficiencies.
3. Oil Analysis – 2 per year
 - a. Complete any required maintenance checklists, report observations to appropriate customer representative.
 - b. Label and complete paperwork indicating present perating conditions.
 - c. Remove sample in approved container.
 - d. Drop off sample for analysis.
 - e. Check with customer representative for operational deficiencies.
4. Refrigerant Sample – 1 per year
 - a. Complete any required maintenance checklists, report observations to appropriate customer representative.
 - b. Label and complete paperwork indicating present perating conditions.
 - c. Remove sample in approved container.
 - d. Drop off sample for analysis.
 - e. Check with customer representative for operational deficiencies.
5. Condenser tube brushing – 1 per year
 - a. Complete any required maintenance checklists, report observations to appropriate customer representative.
 - b. Isolate condenser tube bundle.
 - c. Drain water from condenser tubes.
 - d. Gantry setup.
 - e. Remove condenser heads.
 - f. Mechanically brush each tube.
 - g. Replace head gaskets.
 - h. Replace heads.
 - i. Clean equipment, control panels, and area around equipment after each service.
 - j. Check with customer representative for operational deficiencies

END OF SECTION