

SECTION 15625– CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED

- A. Furnish and install high efficiency, variable speed drive electric centrifugal chiller(s).
- B. The units shall be complete with compressor, condenser and evaporator sections.
- C. The units shall be installed in accordance with all local and State codes.

1.3 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.4 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
 - 1. ARI 550 – Centrifugal or Rotary Water – Chilling Packages
 - 2. ASHRAE 15 – Safety Code for Mechanical Refrigeration
 - 3. ASHRAE 90.1 – Energy Efficient Design of New Buildings
 - 4. ASHRAE 90.2 – Energy Efficient Design of New Low-Rise Residential Buildings
 - 5. ASME (BPV VIII, 1) – Boiler and Pressure Vessel Code, Section VIII, Division 1 – Rules for Construction of Pressure Vassels; 1995.
 - 6. NEMA MG1 – Motors and Generators; 1993 (and Revision 1).
 - 7. UL 465 – Central Cooling Air Conditioners; 1982.

1.5 SUBMITTALS

- A. See Section 15050 and General Conditions for Additional Requirements.
- B. Product Data: Provide rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- C. Shop Drawings: Indicate 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.
- D. Test Reports: Indicate energy input versus cooling load output from 0 to 100 percent of full load (at specified and minimum condenser water temperature).
- E. Provide a drawing indicating how and where to mount the refrigerant sensors.
- F. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.
- G. Manufacturer's Certificate: Certify that components of package not furnished by manufacturer have been selected in accordance with manufacturer's requirements.
- H. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls and accessories. Include trouble-shooting guide.
- I. Product data shall be submitted for approval as follows:
 - 1. Water chiller and accessories.
 - 2. All other auxiliaries.
 - 3. Full load and part load performance data by manufacturer's computer.
- J. The chiller manufacturer shall provide to the Owner the following: A complete set of installation drawings, wiring diagrams and instructions for the equipment, the manufacturer's installation instructions, plus catalog indicating recommended wiring, piping, etc.
- K. The electrical connections shown on the electrical design drawings are based upon a single manufacturer. Additional electrical requirements for other manufacturers for pumps, controls, etc., shall be the responsibility of the HVAC Contractor to coordinate and carry the additional cost to furnish and install all electrical equipment necessary to provide a complete operable system. Additional charges to the Owner will not be acceptable for substitute equipment.
- L. Chillers shall be factory tested.
- M. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum ten (10) years of documented experience.
- B. Provide certification of inspection for conformance to requirements of authority having jurisdiction.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE AND PROTECTION

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

1.8 WARRANTY

- A. All equipment to be furnished in this Section of the specifications shall be guaranteed against defects in material or workmanship for a period of five (5) years from date of initial operation.
- B. This warranty shall include all original equipment mechanically maintainable components such as compressor-motor-rotor-stator, internal gear, oil pump and motor, original equipment controls, purge and motor, float controls. Also included shall be the required maintenance verification inspections per year necessary to maintain the warranty.

1.9 MAINTENANCE SERVICE

- A. Provide service and maintenance of chillers for a period of one (1) year from Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Furnish and install as scheduled microprocessor controlled liquid chillers utilizing a single stage or multi stage semi-hermetic centrifugal compressor using Refrigerant HFC-134a or HCFC-123. Chiller shall include variable speed drive technology. Rotary screw compressor shall not be acceptable. Each chiller shall be provided with a refrigerant monitor regardless of refrigerant type provided.

- B. Acceptable manufacturers subject to compliance with the specification:
 - 1. Trane
 - 2. York
 - 3. Carrier
- C. If a manufacturer proposes a liquid chiller utilizing HCFC-123 refrigerant, the manufacturer shall include:
 - 1. High efficiency purge unit. (Maximum refrigerant emission rate of 0.1 lbs. refrigerant per pound of air.) Purge must be able to operate regardless of main compressor status.
- D. Provide stainless steel relief valve piped to atmosphere.
- E. Five (5) year compressor, motor, and drive warranty.
- F. Chiller performance shall be rated in accordance ARI 550-98 using specified temperatures, specified flows and specified fouling factors.
- G. Equipment and installation shall be in compliance with Safety Code for Mechanical Refrigeration, ANSI/ASHRAE 15 (latest Edition).
- H. Cooler and condenser shall include ASME "U" stamp and nameplate certifying compliance with ASME Section VIII, Division 1 Code for Unfired Pressure Vessels for higher pressure machines only.
- I. Chiller shall be designed and constructed to meet UL or ETL and CSA requirements and have labels appropriately affixed.
- J. Compressor shall be dynamically balanced and over-speed tested by the manufacturer at a minimum of 120% of the design operating speed. Each compressor assembly shall undergo a mechanical run-in test to check proper operation of various components and to verify vibration levels, oil pressures/temperatures, and efficiency are within acceptable limits. Each compressor assembly shall be pneumatically proof tested at a minimum 375 psig and leak tested with a refrigerant tracer gas at 300 psig.
- K. Low pressure machines (HCFC-123): Both cooler and condenser shall be proof tested to 45 psig or 3 times rated pressure and soap and bubble tested. Then test with a mass spectrometer for leaks using helium.
- L. High pressure machines: Both cooler and condenser shall be proof tested at 450 psig on the refrigerant side and leak tested with refrigerant tracer gas at 300 psig.
- M. The water side of each heat exchanger shall be hydrostatically tested at 1.5 times rated working pressure.
- N. The entire chiller assembly shall be leak tested with a refrigerant tracer gas.

- O. Prior to shipment the chiller controls shall be tested under power to verify proper controls operation.
- P. Chillers provided with unit mounted compressor motor starter shall be factory tested under power to verify proper starter operation prior to shipment.
- Q. Unit shall be stored and handled in accordance with manufacturer's instructions.
- R. Unit shall be shipped with all refrigerant piping and control wiring factory installed.
 - 1. Each Chiller shall have:
 - a. A single power connection.
 - b. A single chilled water supply connection.
 - c. A single chilled water return connection.
 - d. A single condenser water supply connection.
 - e. A single condenser water return connection.
 - f. A single point for all BAS control connections.
 - g. Evaporator insulation.
- S. Unit shall be shipped pre-charged with refrigerant and oil as specified on the equipment schedule.
- T. Unit shall be shipped with firmly attached metal plates that indicate name of manufacturer, chiller model number, chiller serial number, and refrigerant used.
- U. The chiller shall be selected to meet or exceed performance requirements as indicated in drawings.
- V. Each chiller shall be provided with hot gas bypass valve and piping, designed to artificially load the evaporator, to permit chiller operation from 100% capacity down to 0% capacity for extended periods of time.

2.2 CHILLER

- A. Factory assembled, single-piece, liquid chiller shall consist of compressor, motor, lubrication system, cooler, condenser, initial oil and refrigerant operating charges, microprocessor control system, and documentation required prior to start-up. Compressor motor variable speed drive/starter shall be mounted on the chiller, wired, and tested by the chiller manufacturer.
- B. Compressor, motor and transmission shall be hermetically sealed into a common assembly or open motor driven and arranged for easy field servicing. Internal compressor parts shall be accessible for servicing without removing the compressor from the chiller. Connections to the compressor shall be flanged or bolted for easy disassembly.
- C. Gears shall conform to AGMA 421.

- D. The compressor design shall include a balancing piston to offset impeller thrust forces. The gear thrust load shall act opposite to impeller thrust loads.
- E. The variable inlet guide vanes at the inlet to the impeller shall provide capacity modulation from 100% to 15% capacity, with 2.5°F drop in entering condenser water temperature per 10% capacity reduction, while also providing pre-whirl of the refrigerant vapor entering the impeller for more efficient compression at all loads.
- F. Acoustical attenuation shall be provided as required to achieve a maximum full load sound level of 89 dBA, measured per ARI Standard 575 (latest edition). Attenuation shall be designed to be easily removed and reinstalled.

2.3 MOTOR

- A. Compressor motor shall be of the hermetic liquid refrigerant cooled (or open) squirrel cage induction type suitable for the voltage shown on the equipment schedule. If open motors are used in place of refrigerant cooled motors, the manufacturer shall supply a curve of motor heat loss as a function of load.
- B. A mechanical room safety alarm, wiring and chiller emergency shutdown shall be included to prevent chiller operation if machine room temperature exceeds 104°F.
- C. A break glass chiller emergency shutdown switch shall be provided and located just outside the refrigeration room.
- D. If the chiller is an open drive type, a motor compressor shaft seal leakage containment system shall be provided. An oil reservoir shall collect any oil and refrigerant that leaks past the seal. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing. Manufacturer shall warrant the shaft seal, reservoir, and float valve system against leakage of oil and refrigerant to the outside of the chiller for a period of (5) years from initial start-up, including parts and labor to replace a defective seal and any refrigerant required to trip the charge to original specifications.
- E. Motor design speed shall be 3550 rpm at 60 Hz. Motors shall be provided with one winding temperature sensor per phase. The temperature of each phase shall be displayed at the unit control panel. Power factor shall be a minimum of 0.89. Motors shall have Class F insulation.
- F. Motor stator shall be arranged for service or removal with only minor compressor disassembly and without breaking of main refrigerant piping connections.
- G. Motors shall be suitable for connection to variable speed drive type starters.

2.4 COOLER AND CONDENSER

- A. Cooler and condenser shall be of shell-and-tube construction, each in separate shells. Both heat exchangers shall be fabricated with high-performance tubing, steel shell and tube sheets.
- B. Tubing shall be copper, high efficiency type with integral internal and external enhancement. Tubes shall be nominal 3/4" O.D. with minimum wall thickness of .028" measured at the root of the fin. Tubes shall be rolled into tube sheets and shall be individually replaceable. Tube sheet holes shall be double grooved for joint structural integrity. Cooler tubes shall be expanded into intermediate support sheets. Intermediate support sheet spacing shall not exceed 36".
- C. Nozzle connections shall be designed for 150 psig maximum working pressure, unless otherwise noted. Nozzles should have grooves to allow use of victaulic couplings.
- D. Evaporator shall be provided with Marine type water boxes that allow the heads to be removed without disassembling any piping.
- E. Condenser shall be provided with Marine type water boxes that allow the heads to be removed without disassembling any piping.
- F. For high pressure machines, the vessel shall display an ASME nameplate which shows pressure and temperature data and the "U" stamp for ASME Section VIII, Division 1. Pressure relief valve shall be installed on each heat exchanger.
- G. Water nozzles shall have vents, 2" drains with valves and covers to permit tube cleaning within the space shown on the drawings. A temperature sensor shall be factory installed in each water nozzle.
- H. Cooler shall be designed so as to prevent liquid refrigerant from entering the compressor.
- I. Tubes shall be individually replaceable from either end of the heat exchanger without affecting strength and durability of the tube sheet and without causing leakage in adjacent tubes.
- J. A compressor discharge isolation valve shall be factory installed to allow isolation of the refrigerant charge in the condenser.
- K. The fouling factors shall be:
 - 1. Condenser 0.001 hr. ft.² °F/Btu
 - 2. Evaporator. 0.0005 hr. ft.² °F/Btu

2.5 CONTROLS, SAFETIES AND DIAGNOSTICS

- A. The chiller shall be provided with a factory installed and wired microprocessor control center with individually replaceable modular component construction. Coordinate with ATC Contractor.
- B. The microprocessor shall be configurable to display either English or SI metric units.
- C. The display screen shall individually indicate the following information in the English language without the use of codes:
 - 1. Date and time of day
 - 2. 48-character primary system status message
 - 3. 48-character error 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)
 - 14. Condenser water differential pressure.
 - 15. Chilled water differential pressure.
 - 16. Temperature of each bearing.
 - 17. Temperature of each phase's winding.
- D. A minimum of (4) function keys shall be software driven within the Status, Schedule, Set point and Service menu structures (as described below).
 - 1. Status Function: In addition to the default screen, status screens shall be accessible to view the status of every point monitored by the control center including:
 - a. Evaporator pressure
 - b. Condenser pressure
 - c. Compressor discharge temperature
 - d. Motor winding temperature
 - e. Number of compressor starts
 - f. Control point settings
 - g. Discrete output status of various devices
 - h. (16) Spare input channels
 - i. Compressor motor starter status
 - 2. Schedule Function: By BAS System
 - 3. Set point Function: The leaving chilled water set point, entering chilled water set point and demand limit set point shall be entered, stored, viewed or changed by depressing

the set point function key. The operator shall be able to modify these set points by entering the set point function and modifying the set points anytime during chiller operating or shutdown periods at the machine or through the BAS.

4. Service Function: By depressing the service function key and entering a 4-digit password the operator shall be able to:
 - a. View the alarm history file which contains up to (25) alarm/alert messages with time and date stamp.
 - b. Execute the chiller controls test function for quick identification of malfunctioning components.
 - c. View/modify chiller configuration.
 - d. View/modify chiller occupancy periods.
 - e. View/modify schedule holiday periods.
 - f. View/modify schedule override periods.
 - g. View/modify system time and date.
5. Upon request to start the compressor, the control system shall start the chilled water pump, condenser water pump, verify that flow has been established and if necessary start the tower fans. The controller shall then compare leaving chilled water temperature with the chilled water control point. If the chilled water temperature is less than the chilled water set point, the control system will shut down the condenser water pump and tower fans and wait for the cooling load to be established.
6. A user-configurable ramp loading rate, effective during the chilled water temperature pull down period, slows the rate of slide valve opening to prevent a rapid increase in compressor power consumption. Ramp loading limits the rate (degrees/minute) of chilled water temperature pull down or percent demand limit to the user configurable rate. During the ramp loading period, a message shall be displayed informing the operator that the chiller is operating in ramp loading mode.
7. The control system shall automatically cycle the compressor off to minimize energy usage whenever the leaving chilled water temperature is 5°F below the desired chilled water set point. The chilled water pump will remain on, and when the leaving chilled water temperature rises above the set point by a user-configured amount, the compressor will automatically be recycled back on. During the shutdown period, a message shall be displayed informing the operator a recycle restart is pending.
8. The control center will monitor line voltage and if loss of voltage, high or low line voltage, or single cycle dropout is sensed, the chiller will shut down. Upon restoration of line voltage, if the auto-start after power failure algorithm is enabled in the configuration mode, the chiller shall automatically restart and resume the mode of operation prior to shutdown.
9. The control center will allow reset of chilled water temperature set point based on water temperature rise across the evaporator. With the 8-input module the following can also be achieved:
 - a. Chilled water reset based on 4-20 mA signal.
 - b. Chilled water reset based on a remote temperature sensor (such as outdoor air).
 - c. Chilled water reset based on a water temperature rise across the evaporator.

10. When reset is active a message shall be displayed indicating the type reset in effect.
11. The control center will limit amp draw of the compressor to the rated load amps or to a value lower based on the following criteria:
 - a. Demand limited based on a user input ranging from 40% to 100% of compressor rated load amps.
 - b. With the 8-input module, demand limit based on an external 4-20 mA signal.
12. When demand limit is active, a message shall be displayed indicating the source of the demand signal.

2.6 SAFETIES

- A. Unit shall automatically shut down when any of the following conditions occurs:
 1. Motor overcurrent
 2. Over voltage
 3. Under voltage
 4. Single cycle dropout
 5. Low evaporator refrigerant temperature
 6. High condenser pressure
 7. High motor temperature
 8. High compressor discharge temperature
 9. Low oil pressure/level
 10. Loss of cooler water flow
 11. Loss of condenser water flow
 12. Variable speed drive/starter fault
 13. Bearing oil high temperature (each bearing)
- B. The control system shall detect conditions which 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 are out of normal operating range:
 1. High condenser pressure
 2. High motor temperature
 3. Low evaporator refrigerant temperature
 4. High motor amps.
- 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 will revert to normal chilled water control. If during either condition the protective limit is reached, the chiller will shut down and a message will be displayed informing the operator which condition caused the shutdown and alarm.

2.7 DIAGNOSTICS AND SERVICE

- A. The control system shall execute a series of prestart checks whenever a start command is received to determine if pressures, temperatures, and timers are within normal limits, thereby allowing start-up to commence. If any of the limits are exceeded, an alert message will be displayed informing the operator of the cause of the prestart alert.
- B. A self-diagnostic controls test shall be an integral part of the control system to allow quick identification of abnormal system conditions and malfunctioning chiller components. 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 will automatically energize the chilled water pump, condenser water pump and oil pump. The control system will confirm water flow and oil pressure have been established and require operator confirmation prior to proceeding to the next test. In addition to the automated controls test, a thermistor test and transducer test shall allow display on the LCD screen of the actual reading of each transducer and each thermistor installed on the chiller. All sensors will have quick disconnects to allow replacement of the sensor without replacement of entire sensor wire.

2.8 BUILDING CONTROL SYSTEM INTERFACE

- A. The chiller control system shall be hardwired directly to the building control system. Provide necessary hardware converter panel and software to allow full interface with the successful ATC vendor. Interface shall use the ASHRAE Standard Protocol BACNET. Proprietary or other custom translators are not acceptable.

2.9 CHILLER UNIT MOUNTED ADJUSTABLE FREQUENCY DRIVE

- A. A variable speed drive/starter shall be installed, wired and tested at the chiller manufacturer's factory prior to shipment. Customer electrical connections shall be limited to main power leads to the starter, wiring of cooler and condenser flow switches to the chiller control circuit, and wiring water pumps and tower fans to the chiller control circuit.
- B. The variable speed drive shall vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The adaptive capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part-load efficiency by analyzing information fed to it by sensors located throughout the chiller.
- C. General
 - 1. DRIVE shall be a closed-loop, liquid-cooled, microprocessor based PWM design. The DRIVE is both voltage and current regulated. Output power devices: IGBT transistors.
 - 2. Factory mounted on the chiller and ships completely assembled, wired and tested.

3. Drive control shall adapt to the operating ranges and specific characteristics of the
4. Chiller efficiency shall be optimized by coordinating compressor motor speed and compressor inlet guide vane position.
5. Chilled water control and drive control work together to maintain the chilled water setpoint, improve efficiency and avoid surge.
6. If a surge is detected, drive surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.

D. Provide the following features

1. NEMA 1 ventilated enclosure with a hinged, locking door is tested to a short circuit withstand rating of 100,000 AIC.
2. A padlockable door-mounted circuit breaker/shunt trip with AIC rating of 100,000 amps. The entire package is UL/CUL listed.
3. Rated for 480/60/3 input power, +/-10%, with a drive overload capability of 100% continuous to 150% for five seconds.
4. Motor thermal overload protection 102% continuous, 140% for 1.5 seconds, 108% for 60 seconds.
5. Minimum efficiency of 97% at rated load and 60 hertz.
6. Soft start, linear acceleration, coast to stop.
7. Adjustable frequency from 38 to 60 hertz.
8. All control circuit voltages are physically and electrically isolated from power circuit voltage.
9. 150% instantaneous torque available for improved surge control.
10. Output line-to-line and line-to-ground short circuit protection.
11. Line dip ride through.
12. The chiller unit controller shall provide for the control/configuration interface to, and the retrieval/display of, drive-related data. DRIVE standard design features controlled through the chiller controller include:
13. Current limited to 100%.
14. Motor overload protection.
15. Motor over temperature protection.
16. Automatic restart after a power outage or power dip.
17. Loss of follower signal – in the event of loss of input speed signal the DRIVE will default to preset or hold speed based on last reference received.
18. Phase loss, reversal, imbalance protection.
19. Overvoltage, undervoltage protection.
20. Digitally displayed on the chiller controller: output speed in hertz, output speed in rpm, input line voltage, input line kw, output/load amps, average current in % RLA, load power factor, fault, DRIVE transistor temperature.
21. Input displacement power factor will exceed .96 regardless of speed and load.
22. Provide a Input Line Reactor in a NEMA 1 enclosure, 5% impedance.
23. Environmental ratings:
 - a. 32F to 104 (0C to 40) operating ambient temperature.
 - b. Altitude to 3300 feet (1000m), amperage derate of 1% per every 300 feet above 3300 feet.

c. Humidity, 95% non-condensing.

E. Harmonic control

1. Active filter shall be unit mounted.
2. The unit short circuit withstand rating shall be a minimum of 100,000 AIC.
3. Integrated active rectification control of the building AC power assures low line-generated harmonics back to the users power grid.
4. DRIVE shall have less than or equal to 5% current harmonic distortion (TDD) at the DRIVE. This shall mean that the PCC for testing Harmonics shall be the power connection to the drive.
5. Voltage Harmonic distortion shall be less then 3% at PCC.
6. Active input rectifier will regulate a unity displacement power factor of .99 or better.
7. Full motor voltage is applied regardless of the input voltage.

2.10 ELECTRICAL REQUIREMENTS

- A. It shall be the responsibility of the HVAC Contractor to furnish the Electrical and ATC Contractor with all wiring requirements to be performed as specified hereinafter.
- B. Electrical contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, electrical protection devices per local code requirements and indicated necessary by the chiller manufacturer. If a chiller is supplied with a remote starter, the Electrical Contractor shall provide power to the starter and interconnecting wiring between the starter and the chiller.
- C. ATC Contractor shall wire the water flow switches to the chiller control circuit to ensure that chiller will not operate until flows are established and maintained.
- D. ATC Contractor shall wire the chilled water pump, condenser water pump, and tower fan control circuit to the chiller control circuit.
- E. ATC Contractor shall supply and install electrical wiring and devices required to interface the chiller controls with the building control system.
- F. Electrical power shall be supplied to the unit by the Electrical Contractor at the voltage, phase and frequency listed in the equipment schedule.

2.11 PERFORMANCE TEST AND REQUIREMENTS

- A. The chiller manufacturer shall conduct a full load performance acceptance test for each chiller and to certify the performance submitted.
 1. The testing shall be done at the manufacturer's factory.
 2. The test shall be conducted in accordance with ARI 550-98 Standard

3. Test instrumentation shall be calibrated and traceable to the National Bureau of Standards.
4. All documentation verifying NBS traceability shall be included in a bound folder for presentation to the Owner and Engineer.
5. The test shall be a design temperatures (adjusted for fouling) and loads.
6. Submit performance at full load for verification of capacity and energy consumption.
7. Performance tests shall be based on the schedule design conditions with the entering condenser water temperature varying as per the schedules.
8. Motor input kW shall be measured on the line side of the variable speed drive device, and active harmonic filter if applicable.
9. **Test shall include standard ARI tolerances except as follows:**
 - a. **The tolerances for condenser water flow shall be within plus or minus 2.0 percent.**
 - b. **The tolerances for Condenser water Temperature adjusted for fouling plus ½°F and minus 0.0°F**
 - c. **The tolerances for Evaporator water flow shall be within plus or minus 2.0 percent.**
 - d. **The tolerances for chilled water Temperature adjusted for fouling plus 0.0°F and minus ½°F**
 - e. **The tolerances for maximum motor input kilowatts that will be acceptable for the chiller shall be as listed on the performance schedule (not 5% over).**
 - f. **The minimum tonnage that will be acceptable for the chiller shall be as listed on the performance schedule (not 5% less).**
 - g. **The KW/Ton shall be as specified or better.**

B. Testing points

1. Specified full load with 85°F condenser water (adjusted for fouling).
2. Chiller minimum load without condenser water relief and without hot-gas bypass (85°F condenser water adjusted for fouling). Chillers that do not meet at least 25% will be unacceptable. This test shall start at full load and then the chiller load slowly lowered holding the condenser water temperature until the unit surges and record that point.
3. 50% load with 80°F condenser water (adjusted for fouling). ARI tolerances
4. 20% load with 75°F condenser water (adjusted for fouling).

C. The test shall be witnessed by representatives of the contractor, engineer and owner. All expenses for travel Lodging shall be at the manufactured expense.

D. Payment for the machine will not be authorized until a satisfactory performance test is approved by the Engineer and the Owner.

2.12 PIPING REQUIREMENTS - INSTRUMENTATION AND SAFETIES

- A. The HVAC Contractor shall supply and install pressure gauges in readily accessible locations in piping adjacent to the chiller such that they can be easily read from a standing position on the floor. Gauges shall be Marsh Master or equal with 4 1/2" nominal diameter face. Scale range shall be such that design values shall be indicated at approximately mid-scale.
- B. Gauges shall be installed in the leaving water piping of the cooler and condenser.
- C. The HVAC Contractor shall install flow detection devices in chilled water and condenser water piping. Switches shall be differential type. Switches shall be installed in horizontal runs at least (5) pipe diameters downstream from any bend or tee.

2.13 INSULATION

- A. Chilled water piping and cooler water boxes shall be insulated by the Chiller Manufacturer.
- B. Chillers provided without factory insulation shall be insulated at the jobsite per manufacturer's instructions.
- C. Insulation shall be 1 1/2" thick, shall have a maximum thermal conductivity of 0.28 btu/inches/hour/sq.ft. and shall conform to UL 94/94HBF.

2.14 HIGH PRESSURE REFRIGERANT RECYCLE RECLAIM SYSTEM

- A. Provide a refrigerant recycle and reclaim system to serve the positive pressure type water chilling unit.
- B. The transfer system shall be factory assembled with a reciprocation electric motor driven vacuum pump, water-cooled condenser, a motor controller, and adequate control for safe and efficient operation.
- C. The transfer system shall be connected by valves and piping with all evaporators and receiver. The vacuum pump motor shall be suitable for operation on voltage shown on the drawing. Vacuum pump shall be at least 13 cfm and capable of producing a vacuum of 29.9 inches of Hg.
- D. The pump-out receiver provided in conjunction with the transfer system shall be horizontal type, epoxy-lined and sufficiently sized to accommodate the complete refrigerant charge of 110% of the largest water chilling unit
- E. The receiver shall have relief valves in accordance with the latest edition of the ANSI B9.1 Code.
- F. Provide clean-outs, replaceable core type filter-drier, moisture indicator, and a blanket shell heater.

- G. Design shall be in accordance with ASME Code for unfired pressure vessels. The refrigerant piping, valves, etc. between evaporators and pump-out receiver shall be shown on the Shop Drawings. Submit a complete piping diagram for review.
- H. Provide a minimum ¾” service fitting on both the evaporator and condenser shell. The Contractor shall furnish and install necessary refrigerant piping, valves, and fittings to interconnect evaporators and pump-out condenser.
- I. Provide all necessary electrical disconnects, motor controllers, wiring, etc. utilizing materials and methods specified in Division 16.

2.15 APPROVED SCBA DEVICE

- A. Provide two (2) industrial grade Workmask II Self-Contained Breathing Apparatus (SCBA) shall be provided as an OSHA approved re-entry device as required by ASHRAE Standard 15-1994. The SCBA shall be of the type using compressed air and shall be jointly certified by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) under Subpart H, 30 CFR, Part II for 30 minute- rated service life. The apparatus shall be certified for use at temperatures above -25F.
- B. The SCBA shall consist of the following parts:
 - 1. A single lens faceplate with speaking diaphragm and detachable breathing tube.
 - 2. Pressure demand regulator.
 - 3. High pressure regulator.
 - 4. Audible warning bell.
 - 5. Compressed air tank.
 - 6. Harness assembly.
 - 7. Wall mounted storage case with hinged door.
- C. The SCBA mask faceplate shall be suitable for use with refrigerant. The faceplate material shall remain clear and not opaque when subjected to liquid refrigerant spray for 30 seconds. The mask shall have a built in speaking diaphragm with provision for a interconnection with a portable radio.
- D. The SCBA tank shall be fabricated of aluminum construction and shall be 30 minute rated at 2216 psig. The tank shall include a tank harness including adjustable waist and shoulder straps.
- E. The SCBA shall include all documentation needed to ensure compliance with OSHA training and maintenance requirements. This includes but is not limited to; Donning Chart, Warranty Card, Factory Flow Test Results, Safety Precautions, Product Information Bulletin, Inspection and Maintenance Procedures, Parts List, Air Mask, Maintenance Check List Card, and Maintenance Check List Sheet.
- F. The SCBA documentation shall include a operator training VHS video tape.

- G. The SCBA shall be provided with a self-supporting fiberglass wall case. The case shall have the capacity to contain either one or two SCBA(s) as indicated in the schedule.

2.16 VIBRATION ISOLATION

- A. The HVAC Contractor shall provide vibration isolation and seismic restraints as hereinbefore specified under Section 15241 of these specifications.

2.17 INSTALLATION

- A. In accordance with manufactures written instructions and recommendations.
- B. Coordinate location and all required clearances and code clearances required.
- C. Coordinate and provide all interlock wiring.
- D. Provide refrigerant relief lines in accordance with ASHRAE 15, local codes, and manufactures recommendation.
- E. 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.
- F. Provide classroom instruction for a minimum of (8) hours to instruct the Owner's personnel in the proper operation and maintenance of the chiller.
- G. The HVAC Contractor shall supply the Owner with the following literature as furnished by the manufacturer prior to start-up:
 - 1. One (1) complete set of installation drawings
 - 2. Field wiring diagrams
 - 3. Installation instructions
 - 4. Start-up, operation and maintenance instructions
- H. The SCBA(s) in their fiberglass case(s) shall be mounted so that they are at accessible at the locations identified.

2.18 REFRIGERANT MONITOR

- A. The HVAC Contractor shall furnish and install a refrigerant monitor complete with all sensors, relays, panels, etc.
- B. The ATC Contractor shall wire all components pertinent to the monitor system including all sensors, alarms (audio and visual) and interlock to chiller room purge fan.

- C. Compound specific type of system required.
- D. Entire installation to comply with the Safety Code for Mechanical Refrigeration ASHRAE Standard 15, 1992.
- E. Refrigerant Monitor
 - 1. Acceptable Manufacturers Contingent on Compliance with Specifications
 - a. Trane RMWD
 - b. Yokogawa Corp.
 - c. Mine Safety Appliances Model "Chillgard IR"
 - d. Delta F Corp, Series 500
 - 2. Alternate Monitors
 - a. Alternate sensors must be approved prior to bid and meet the following criteria:
 - 3. Monitor shall be user programmable for specific compounds with a measurement and display range 0 to 1000 ppm.
 - 4. The monitor must be calibrated for the specific refrigerant.
 - 5. The display accuracy shall be ± 1 ppm.
 - 6. Two (2) factory set alarm levels shall be provided, each with a front panel light and a latching binary contact closure for the control of remote devices.
 - 7. An analog output corresponding to the unit display is required for connection to a BAS or other recording equipment.
 - 8. A means to automatically re-zero the instrument must be included.
 - 9. Regular maintenance of the unit shall be limited to recalibration (1) time per year and monthly confirmation of clean air source for recalibration.
 - 10. Ambient temperature operating range shall be 40 to 105°F.
 - 11. The panel shall provide for the monitoring of a minimum of six (6) locations.
 - 12. The sensor technology shall be of the infrared non-dispersive type.
 - 13. An internal disk drive shall record the daily peak levels in PPM along with the time, date and area sensed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Start-Up Service
- B. The manufacturer shall furnish a factory trained service technician without additional charge for a minimum of five (5) days per chiller. Units that are factory charged will not require field evacuation, dehydration and charging of the system.

- C. Manufacturer shall provide instruction of the Owner's personnel on the operation and maintenance of the unit. Manufacturer shall provide operating instructions and parts lists of required parts for routine maintenance over a period of three (3) years.
- D. Warranty shall include all inspections, troubleshooting and all parts and the labor to install faulty parts. Refrigerant shall also be included and the labor to add refrigerant to the system.

END OF SECTION