**SECTION 236416 – CHILLERS**

Latest Update 08-16-2020 See Underlined Text for Edits

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off all "Underlines".)

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

### 1.2 SUMMARY

A. This section includes the requirements for chillers and accessories as follows:

<Edit for Project Requirements>

1. Packaged, water cooled, electric motor driven centrifugal chillers.
2. Oxygen Monitor.
3. Refrigerant Monitoring System.
4. Packaged air cooled water chillers.

### 1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. <Delete seismic requirements if the not required.>
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Performance: Performance indicated is net cooling available after subtracting any chiller auxiliary cooling requirements. Energy use is the total energy used, including energy required to meet any chiller auxiliary cooling requirements.

C. Open Drive Units versus Sealed Drive Units: Chillers with open drives shall be selected with sufficient additional cooling capacity beyond the capacity indicated in the construction documents to provide the additional cooling needed to offset the rejected motor heat load into the room. The vendor shall be responsible for the cost of the equipment needed to accomplish this cooling. The chillers kw/ton shall reflect this extra cooling requirement in their calculations.

D. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of $60^0$F and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of $60^0$F.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

## 1.4 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, performance data, rated capacities, refrigerant type, factory mounted controls, factory mounted VFD's, installation instructions, wirings diagrams, power requirements, specified options, and warranty information.

B. LEED Submittals: <Delete if not LEED project.>

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

## 1.5 INFORMATIONAL SUBMITTALS

A. Certificates: For certification required in "Quality Assurance" Article.

1. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
2. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. ARI Test Results: Provide ARI test results for both standard test and added test.
6. Startup service reports.
7. Warranty.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

1.7 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 550 certification program.

B. ARI Rating: Rate chiller performance according to requirements in ARI 506/110.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/ISESNA 90.1.

E. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include an ASME U stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.

1.8 WARRANTY/GUARANTEE

A. General: In addition to the warranty requirements in Division 23 Specification Section "Basic Mechanical Requirements – HVAC", the following extended warranties shall be included by the chiller manufacturer:

1. Manufacturers Maintenance and Service Agreement - Leak Tight Refrigerant Warranty: The chiller manufacturer shall provide a leak tight refrigerant warranty for a period of five (5) years, including parts and labor, from the date of substantial completion. During the specified warranty period, if a leak is determined, the manufacturer's representative covering the warranty will be notified and the representative shall repair/replace the source of the leak, replace the lost refrigerant, and place the unit back in operation. The liability shall include the purchase price of the refrigerant lost in excess of 0.0% per year. This warranty shall cover refrigerant replacement costs when the loss is due to a leak in the machine and shall include replacement parts and labor costs to repair the leak and install the refrigerant. After the warranty period the leak tight warranty shall remain in effect at no additional cost if the chiller has at all times since its purchase, been covered by a comprehensive service and maintenance agreement from one of the equipment manufacturer's local representatives. This warranty shall continue as long as the service and maintenance agreement from the equipment manufacturer remains in place.

2. Extended Parts/Labor/Refrigerant Warranty: The chiller manufacturer shall provide a whole unit parts, controls, labor and refrigerant warranty for a period of five (5) years from the date of substantial completion. The chiller manufacturer shall provide an original factory warranty certificate for each chiller listing as a minimum chiller model, serial number, and warranty information as specified. Payment will not be released until the owner receives original certificates. Warranty coverage shall be per the factory, not local sales offices.
3. Inclusion for Open Drive Machines: For open drive machines the chiller manufacturer shall include a shaft seal full parts, labor, & refrigerant warranty for seven (7) years from the date of substantial completion. During the warranty period replacement of the shaft seals and related parts shall be completed by the manufacturer and/or their representative covering the warranty. The replacement of refrigerant shall be included.

## PART 2 - PRODUCTS

### 2.1 GENERAL PRODUCT REQUIREMENTS

A. Chiller Design and Selection: Chiller(s) shall be designed and selected in accordance with the scheduled capacities on the drawings and the requirements of this specification for base bid chillers and for add alternate high performance chillers to produce the specified maximum tonnage (and any additional capacity required for open drive units) at the specified maximum electrical power input at 100% full load when tested in accordance with ARI certified test criteria. The unit shall bear the ARI certification label as herein specified.

B. Base Bid Centrifugal Water Cooled Chillers: Subject to compliance with requirements, provide standard performance chillers by one (1) of the following: <Delete if not required for Project>

1. Trane - HCFC – 123
2. Carrier Corporation – HFC – 134a
3. York International – HFC – 134a

C. Add Alternate [Insert #] High Performance Centrifugal Water Cooled Chillers: Subject to compliance with requirements, provide high performance chillers by the following: <Delete if not required for Project>

1. Trane - HCFC – 123

D. Air Cooled Chillers: Subject to compliance with requirements, provide air cooled chillers by one (1) of the following: <Delete if not required for Project>

1. Trane – R410a
2. Carrier Corporation – R410a
3. York International – R410a

E. Performance: Performance indicated is net cooling available after subtracting any chiller auxiliary cooling requirements. Energy use is the total energy used, including energy required to meet any chiller auxiliary cooling requirements.

2.2 CENTRIFUGAL WATER COOLED CHILLERS <Delete if not required for Project>

A. Manufactured Units: <Edit for Project.>

1. Description: Factory assembled and tested chiller complete with compressor, compressor motor, compressor motor controller, lubrication system evaporator, condenser, <heat reclaim condenser as indicated,> controls, interconnecting unit piping and wiring, and indicated accessories.
<Retain first subparagraph below if limited space is available for installation.>

a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
b. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor drive assembly fails or is being serviced.

B. Compressor Drive Assembly: <Edit for Project.>

1. Description: Single stage or multistage, variable displacement, centrifugal type compressor driven by an electric motor.
2. Base Bid: Under base bid hermetically sealed motor designs, open motor designs and/or hot gas motor cooling are acceptable.
3. Add Alternate [Insert #]: Under add alternate [Insert #] the motor shall be hermetically sealed two (2) pole low slip squirrel cage, induction type and either suction or liquid refrigerant cooled. Open rotor designs and/or hot gas motor cooling will not be acceptable.
4. Where indicated, provide oil free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls. <Retain this paragraph if specifying oil free>
5. Where open drive machines are provided (base bid only) the cost of the machines must include the cost of air handling units, including coils, filters, piping, power and controls, in the equipment room to offset the heat gain to the space from the open drive machines.

C. Compressor:

1. Casing: Cast iron, precision ground.
2. Impeller: High strength cast-aluminum alloy on carbon or alloy steel shaft.
3. Impellers shall be dynamically balanced and over-speed tested at 1.25 times impeller shaft speed.

D. Drive: Direct or gear drive, open or hermetic design using an electric motor as the driver.

1. Gear Drives: For chillers with gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards.
2. Drive Coupling: For chillers with open drives (base bid only), provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
3. Seals: Seal drive assembly to prevent refrigerant leakage.

E. Compressor Motor:

1. Continuous duty, squirrel cage, induction type, two (2) pole motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with open drip proof enclosure.
5. Provide motor with thermistor or RTD in single motor winding to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.

F. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

1. Over speed Test: 25% above design operating speed.
2. Compressor assembly shall be run-tested at the factory. Vibration shall not exceed 1.0 mil peak to peak.
3. Manufacturers with speed increasing transmissions shall not exceed 10,000 RPM compressor speeds.

G. Service:

1. Compressor's internal components shall be accessible without having to remove compressor drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

H. Economizers: For multistage chillers, provide interstage economizers. <Delete if economizer is not required.>

I. Capacity Control: Provide modulating, variable inlet, guide vane assembly combined with hot gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy efficient operation possible.
2. Operating Range: From 100% to 10% of design capacity. Chiller shall be able to unload to l0% of scheduled conditions by means of variable inlet guide vanes. Designs which cannot reach 10% unloading shall employ hot gas bypass and shall be selected at 5% KW/ton less than specified to account for hot gas bypass energy.
3. Chillers with variable frequency controllers shall modulate compressor speed with variable inlet, guide vane control to achieve optimum energy efficiency.

J. Oil Lubrication System: Consisting of pump, filtration, heater, cooler, factory wired power connection, and controls. Provide the following:

1. Provide Lubrication to for bearings, gears, and other rotating surfaces at all operating, startup, coast down, and standby conditions including power failure.
2. Manufacturer's standard method to remove refrigerant from oil. <insert manufacturers oil removal method>
3. Oil filter shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
4. Refrigerant or water cooled oil cooler. <Edit for Project.>
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.
8. Starters for oil pumps which require a separate power supply. Pump shall operate prior to startup.
9. Low watt density heater shall maintain the oil temperature to minimize its affinity for refrigerant.
10. Oil cooling shall be provided by the refrigerant.
11. Provide service valves to enable replacement of oil filter(s) without removal or pumping of refrigerant charge.
12. A full charge of oil shall be provided to be installed following chiller re-assembly.

K. Refrigeration:

1. Type: R-123; ASHRAE 34, Class B1 or R-134a; ASHRAE 34, Class A1.
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Where site conditions require chillers to be field assembled provide a full refrigerant charge which shall be installed following chiller’s re-assembly. <Delete if not required>
4. Provide factory connections for reclaim and removal of refrigerant during service in accordance with ASHRAE 15.

L. Refrigerant Flow Control: Manufacturer's standard refrigerant flow control device satisfying performance requirements indicated.

1. Liquid refrigerant flow control shall be either variable orifice, thermal expansion valve, or multiple fixed orifices. Liquid sight glass shall be located upstream of the control device to monitor refrigerant flow and moisture indication.

M. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.
2. A non - fragmenting rupture disk shall be provided for high pressure emergency relief in accordance with ASHRAE 15. In addition, a spring operated high pressure relief valve shall be provided downstream of the non - fragmenting rupture disk. The relief valve shall be sized and rated for the pressure appropriate to the vessel operating conditions in accordance with ASHRAE, ARI, ASME, and shall be designed to re-set at a pressure below the high pressure relief setting to prevent the loss of the entire refrigerant charge.
3. Provide a sensor between the rupture disk and the relief valve and wire to BAS to indicate disk failure/trouble.
4. For Chillers Using R-123: Spring loaded, pressure relief valve; single or multiple reseating type.
5. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

N. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

O. Refrigerant Isolation for Chillers Using R-134a: Factory install positive shutoff, manual isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.

P. Purge System: <HCFC-123 machines only>

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables including, but not limited to, water, water vapor, and noncondensable gases.
2. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
3. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.

4. Construct components of noncorrodible materials.
5. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
6. The purge unit shall be able to operate when the machine and pump are off.
7. The purge tank shall include a cooling coil, filter drier cores, water separation tube, sight glass, drain, and air discharge port.
8. Any excess purge requirement shall enable a fault indication light at the purge and shall enable the general alarm contact closure for remote annunciation.

    a. The unit indication shall include:

        1) Lights indicating condenser running, fault indication and service operation.
        2) Elapsed time meter (monitor amount of leak rate).
        3) Binary outputs to indicate purging of air from the purge unit and purge shutdown due to excessive operation.

9. At standard operating conditions and with a condensing refrigerant temperature 80ºF, the purge shall be rated for no more than 0.1 lbs of refrigerant per pound of purged air.
10. Purge unit shall be connected to a 100% reclaim device. Outside venting is not acceptable.
11. The purge unit relief piping shall be from the 100% reclaim device to the chiller refrigerant relief line downstream of the refrigerant relief valve.
12. Efficiency of not more than 0.02 lb of refrigerant per pound of air when rated according to ARI 580.
13. Operation independent of chiller per ASHRAE 147.

Q. Positive-Pressure System:

1. For chillers operating at sub atmospheric pressures (using R-123 refrigerant), provide a factory installed automatic positive-pressure system.
2. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than 0.5 psig adjustable up to a pressure that remains within the vessel design pressure limits.
3. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

R. Evaporator and Condenser:

1. Description: Shell and tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
2. Shell Material: Carbon steel rolled plates with continuously welded seams or seamless pipe.

3. Designed to prevent liquid refrigerant carryover from entering compressor.
4. Provide evaporator with sight glass or other form of positive visual verification of liquid refrigerant level.
5. Water side velocity shall not be less than three (3) feet per second nor more than twelve (12) feet per second.
6. Provide lifting lugs on all shell heads.

S. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper.
4. Nominal OD: Three quarter (3/4) or one (1) inch.
5. Minimum Wall Thickness: 0.025 inch.
6. Evaporator Tubes: Evaporator tubes shall be internally and externally enhanced to improve the chiller's energy efficiency.
7. Condenser Tubes: Condenser tubes shall be externally enhanced with smooth internal bore to reduce the cost of tube cleaning.

T. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

U. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

V. Marine Water Box: Hinges, Davit's, Nozzles

1. Marine water boxes shall be provided, for both evaporator and condenser sections, under both Base Bid and Add Alternate [Insert #]. Water boxes shall be designed for a working pressure of 225 psig (minimum) and shall be subjected to a factory hydrostatic pressure test of 350 psig (minimum).
2. Cast iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
3. Marine type for water box with piping connections. Standard type for water box without piping connections.
4. Provide hinges for all water boxes.
5. Nozzle Pipe Connections: Grooved for mechanical joint coupling.
6. Thermistor or RTD temperature sensor factory installed in each nozzle.
7. Fit each water box with three quarter (3/4) inch drain connection at low point and vent connection at high point, each with threaded plug.
8. All water boxes shall be removable for cleaning and shall incorporate lifting eyes or lugs.

W. Insulation: <Edit for Project.>

1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tube and Type II for sheet materials.
   <Second option in subparagraph below may not be available from all manufacturers as a standard factory option. Consult manufacturer.>
   a. Thickness: Three quarter (3/4) inch.
   b. Adhesive: As recommended by insulation manufacturer.

2. Factory Insulation shall be applied over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant cooled motor, and auxiliary piping.
3. Apply adhesive to 100% of insulation contact surface.
4. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
5. Seal seams and joints to provide a vapor barrier.
6. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

X. Electrical:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single point, field power connection to fused disconnect switch.
3. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch.

   a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   b. NEMA AB 1, motor-circuit protector (circuit breaker) with field adjustable, short circuit trip set point.

4. NEMA ICS 2-rated motor controller for auxiliary motors, hand, off, auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable speed motor furnished.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
7. Factory installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a twenty four (24) inch length of liquid tight or flexible metallic conduit.

Y. Unit Mounted Variable Speed Drive (VSD): <Where multiple chillers are used retain this paragraph for one (1) of the multiple chillers coordinate with UMB>

1. Each centrifugal water chiller shall be furnished with a liquid cooled variable speed drive (VSD). The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested. This VFD must also comply with the requirements of Division 26 Specification Section "Variable Frequency Drives".
2. The VSD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VSD control logic shall optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, VSD surge avoidance logic shall make adjustments to move away from and avoid surge at similar conditions in the future.
3. The VSD efficiency shall be 97% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.96.
4. The VSD shall be solid state, microprocessor based pulse width modulated (PWM) design. The VSD shall be voltage and current regulated. Output power devices shall be IGBT transistors.
5. Power semi-conductor and capacitor cooling shall be from a liquid cooled heatsink.
6. Each VSD shall be furnished in a NEMA 1 metal enclosure having as a minimum a short circuit withstand rating of 65,000 amps per UL 508. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.

    a. Enclosure shall include a pad lockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.
    b. The entire chiller package shall be U.L./C.U.L. listed.

7. The VSD shall be tested to ANSI/UL Standard 508 and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.
8. Compliance to recommendations stated in IEEE 519-1992.

    a. The VSD design shall include as standard integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than 5%.

9. Input shall be nominal 480 volts, three phase, 60 Hertz AC power, +/- 10% of nominal voltage.
10. Line frequency 38-60 hertz.
11. The VSD shall include the following features:

    a. All control circuit voltages shall be physically and electrically isolated from power circuit voltage.
    b. 150% instantaneous torque shall be provided for surge control.

c. Minimum and maximum speed adjustments.
d. Soft start, adjustable linear acceleration, coast to stop.
e. Adjustable current limiting and UL approved electronic motor overload protection.
f. Insensitivity to incoming power phase sequence.
g. VSD and motor protection from the following faults:

1) Output line to line short circuit protection
2) Line-to-ground short circuit protection
3) Phase loss at AFD input
4) Phase reversal/Imbalance
5) Over-voltage
6) Under-voltage
7) Over temperature

h. Carrier frequency shall be fixed at 2 Khz for maximum efficiency.
i. Automatic operation at minimum speed if the input reference is lost.

12. The following VSD status indicators shall be provided to facilitate startup and maintenance:

a. Output speed in hertz and rpm
b. Input line voltage
c. Input line kW
d. Output/load amps
e. Average current in percent RLA
f. Load power factor
g. Fault
h. VSD transistor temperature

13. Service Conditions - at full output power. No external venting or heat exchangers shall be required.

a. Operating ambient temperature 32-104 F (0-40 C).
b. Room ambient 0% - 95% relative humidity.
c. Elevation to three thousand three hundred (3,300) feet, (1000-meters).

14. Metering: Meter shall be Square D Power Logic Meter Model PM750 with remote display and KYZ output. For remote access to the campus metering system provide a Square D Ethernet Gateway, 10/100 BASE TX – Square D Model #EGX100SD w/RS485/RS232 utilizing MOD BUS TCP/IP protocol for communication with the campus metering system.

a. Meter Display: LCD digital meter shall display the following data:

1) Volts (ø-ø and ø-N) and amps (per ø).

2) Real power (kW – both instantaneous and remotely-adjustable average).
3) Reactive power (=kVAr - both instantaneous and remotely-adjustable average).
4) Apparent power (kVA - both instantaneous and remotely-adjustable average).
5) Power factor.
6) Real energy (kWh) reactive energy (kVArh) and apparent energy (kVAh).

b. Metering Transformers: Provide the following:

1) Three (3) current transformers (CT) (for minimum 2.5 element metering).
2) At least two (2) potential transformers (PT) (for minimum 2.5 element metering).

c. Meter Location: Mount meter in control panel cover.
d. Communication Connection: Provide the following:

1) Connect RS-485 communication output to Ethernet Gateway.
2) Power the meter and the Ethernet Gateway from chiller panel control power/UPS.
3) Connect Ethernet gateway to campus facilities Ethernet network via (minimum) CAT5 cable.

Z. Starter - Star Delta (Low Voltage): <Where multiple chillers are used retain this paragraph for one (1) or more of the multiple chillers, coordinate with UMB>

1. Motor starter shall be a Wye-Delta Closed Transition and shall have a gasketed (NEMA 12) painted steel enclosure.
2. Motor starters shall include incoming line provisions for the number and size cables shown on the drawings. Incoming line lugs shall be copper mechanical type. Connection directly to the contactors is not permissible. All components shall be mounted to a removable steel panel of 14 gauge minimum.
3. Contactors shall be sized properly to the chiller full load currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall be low resistance having palladium silver contacts.
4. Each motor starter shall include a 3 KVA control power transformer with fused primary and secondary. Control relays shall be provided within the motor starter to interface with the control panel.
5. Power wiring within the starter shall be type MTW copper stranded 90ºC. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be type MTW copper stranded 90ºC 16 gauge minimum.

6. Starter shall include an advanced motor protection system incorporating electronic three phase overloads and current transformers. This electronic motor protection system shall monitor and protect against the following conditions:

    a. Three phase overload protection.
    b. Overload protection during start-up.
    c. Phase imbalance.
    d. Phase loss.
    e. Phase reversal.
    f. Low voltage.
    g. Distribution fault protection consisting of three-phase, current sensing devices that monitor the status of the current. Distribution faults of 1-1/2 electrical cycle duration shall be detected and the compressor motor shall be disconnected within six electrical cycles.

7. The starter shall be able to operate in temperatures up to 120ºF.
8. All field supplied wires, bus bars, and fittings shall be copper only.
9. The following starter features shall be provided:

    a. Disconnect - Starter shall contain a molded case switch or circuit breaker capable of breaking currents up to its interruption capacity. Operating handle and trip indicator shall be located on the door. This handle shall be capable of being padlocked in the off position.
    b. Metering - Provide an electronic LCD digital meter to display volts (ø-ø and ø-N) and amps (per ø), real power (KW), reactive power (KVAR), apparent power (KVA), power factor, energy (KWH) reactive energy (KVARH) and apparent energy (KVAH). Provide all CT's and PT's with 0.3 % accuracy. Meter shall be Square D Power Logic Meter Model PM-870 with remote display and KYZ output, Model PM-870RD. Mount display in control panel cover.
    c. U. L. 508 approval.
    d. Power Factor Correction Capacitors shall be provided to correct to 93.5% - 95.5% at full load conditions.

AA. Controls:

1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, Type 1, hinged or lockable; factory wired with a single point, field power connection and a separate control circuit.
3. Operator Interface: Multiple character digital or graphic display with dynamic update of information and with keypad or touch sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

a. Date and time.
b. Operating or alarm status.
c. Fault history with not less than last ten (10) faults displayed.
d. Set points of controllable parameters.
e. Trend data.
f. Operating hours.
g. Number of chiller starts.
h. Outdoor air Entering and leaving fluid temperatures of evaporator and condenser.
i. Difference in fluid temperatures of evaporator and condenser.
j. Fluid flow of evaporator and condenser.
k. Fluid pressure drop of evaporator and condenser.
l. Refrigerant pressures in evaporator and condenser.
m. Refrigerant saturation temperature in evaporator and condenser shell.
n. Compressor refrigerant suction and discharge temperature.
o. Compressor bearing temperature.
p. Motor bearing temperature.
q. Motor winding temperature.
r. Oil temperature.
s. Oil discharge pressure.
t. Phase current.
u. Percent of motor rated load amperage.
v. Phase voltage.
w. Demand power (kilowatts).
x. Energy use (kilowatt/hours).
y. Power factor.
z. Output voltage and frequency.
aa. Voltage total harmonic distortion for each phase.
bb. Supply current total demand distortion for each phase.
cc. Inlet vane position.
dd. Controller internal ambient temperature.
ee. Heatsink temperature.

4. Purge suction temperature if purge system is provided.
5. Purge elapsed time if purge system is provided.

BB. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on [return-water] [outdoor air] [space] temperature.
3. Current limit and demand limit.
4. Condenser fluid temperature.
5. External chiller emergency stop.
6. Variable evaporator flow.

7. Thermal storage.
8. Heat reclaim.

CC. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

1. Low evaporator pressure or temperature; high condenser pressure.
2. Low evaporator fluid temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor discharge temperature.
7. Loss of condenser fluid flow.
8. Loss of evaporator fluid flow.
9. Motor overcurrent.
10. Motor overvoltage.
11. Motor undervoltage.
12. Motor phase reversal.
13. Motor phase failure.
14. Sensor or detection circuit fault.
15. Processor communication loss.
16. Motor controller fault.
17. Extended compressor surge.
18. Excessive air leakage detection for chillers using R-123 refrigerant.

DD. Trending: Capability to trend analog data of up to five (5) parameters simultaneously over an adjustable period and frequency of polling.

EE. Security Access: Provide electronic security access to controls through identification and password with at least three (3) levels of access:

1. View only,
2. View and operate,
3. View, operate, and service.

FF. Control Authority: At least four (4) conditions:

1. Off.
2. Local manual control at chiller.
3. Local automatic control at chiller.
4. Automatic control through a remote source.

GG. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

HH. BAS Interface: Factory installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.

1. Hardwired Points:

   a. Monitoring: On/off status, common trouble alarm, electrical power demand kilowatts.
   b. Control: On/off operation, chilled water, discharge temperature set point adjustment electrical power demand limit.

2. Provide BAC Net IP based communication interface with the BAS to enable the UMB Energy Manager o remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall also be displayed through the BAS.

II. Chiller Point List: The following point list shall be made available for remote monitoring, by the chiller manufacturer, from the chiller's control panel to the BAS via BAC NET IP Protocol and is based on data from a Trane Centrifugal Chiller:

1. ADDRESS – Address of Controller
2. APPLICATION – Specific Control Profile
3. ENERGY [kWh] – Energy Consumption in kilowatts per hour
4. TONS – Rate of production in tons
5. TON – HOURS – Volume of production in ton/hours
6. COMMERROR – Communication Error
7. IPADDR1 – IP Address #1
8. IPADDR2 – IP Address #2
9. IPADDR3 – IP Address #3
10. IPADDR4 – IP Address #4
11. IPPORT – IP Port
12. BASE OFFSET – Base Offset (included in #13- SENDINITVAL)
13. SENDINITVAL – Send Initial Value (Initial Setpoint)
14. SOFTWARE – Software Type
15. SFT REV – Software Revisions
16. CHILL RUN – Chiller Running
17. AVG LINE CUR – Unit Average Line Current
18. ACT I LIMIT – Active Current Limit Setpoint
19. POWER USE – Unit Power Consumption
20. ACT HC STPT – Active Cool/Heat Setpoint Temperature
21. EVAP LV TEMP – Evaporator Leaving Water Temperature
22. EVAP ENT TMP – Evaporator Entering Water Temperature
23. COND ENT TEM – Condenser Entering Water Temperature
24. COND LV TEMP – Condenser Leaving Water Temperature
25. EVAP PMP CTL – Evaporator Pump Control
26. EVAP FLOW – Evaporator Water Flow
27. COND PMP CTL – Condenser Pump Control

28. COND WTR FLW – Condenser Water Flow
29. DIAG CODE – AFD Last Diagnostic Code
30. RUN STATUS – Chiller Running Status
31. CTRL MODE – Chiller Control Mode
32. STPT SOURCE – Setpoint Source
33. ACTCHW SP SR – Active Chiller Water Setpoint Source
34. ACTLMT SP SR – Active Current Limit Setpoint Source
35. ACT BL SP SR – Active Base Loading Setpoint Source
36. PANEL STOP – Front Panel Auto/Stop
37. PANEL MODE – Front Panel Chiller Control Mode
38. PANEL STPT – Front Panel Chilled Water Setpoint
39. PANEL I LIM – Front Panel Current Limit Setpoint
40. PANEL HW SP – Front Panel Hot Water Setpoint
41. EXT STOP – External Auto Stop
42. EMEG STOP – Emergency Stop
43. MAN OVR XIST – Manual Override Exists
44. ALARM – Alarm Present
45. CHLR IN AUTO – Chiller in Auto
46. LOC STPT – Local Setpoint Control
47. MAX CAP RLY – Maximum Capacity Relay
48. LIM MODE RLY – Limit Mode Relay Status
49. HEAD RLF REQ – Head Relief Request Relay
50. COMP RUN – Compressor Running
51. EVAP PRESS – Evaporator Refrigerant Pressure
52. COND PRESS – Condenser Refrigerant
53. RFG DIFF PRS – Differential Refrigerant Pressure
54. OIL TNK PRS – Oil Tank Pressure
55. OIL PMP PRS – Oil Pump Discharge Pressure
56. OIL DELTA P – Oil Differential Pressure
57. OIL TANK TMP – Oil Tank Temperature
58. EVAP SAT TMP – Evaporator Saturated Refrigerant Temperature
59. COND SAT TMP – Condenser Saturated Refrigerant Temperature
60. COMP RFG TMP – Condenser Refrigerant Discharge Temperature
61. IGV1 POS – IGV1 Position
62. PRG RLY – Purge Compressor Relay
63. PMPOUT RLY – Pumpout Relay
64. PRG REG VLV – Purge Regenerative Valve Solenoid
65. CARB TANK TMP – Purge Carbon Tank Temperature
66. PRG LIQ TMP – Purge Liquid Temperature
67. PRG SUCT TMP – Purge Refrigerant Compressor Suction Temperature
68. NEXT PRG TIM – Time Until Next Purge Run
69. PO CHLR ON7 – Pumpout Chiller On – Seven (7) Days
70. PO CHLR OFF7 – Pumpout Chiller Off – Seven (7) Days
71. DAY PMP 24H – Daily Pumpout – Twenty Four (24) Hours
72. PMP OUT LIFE – Pumpout – Life

73. RFG LIFE – Refrigeration Life
74. COMP STARTS – Compressor Starts
75. COMP RT – Compressor Running Time
76. STRT AB V – Starter Voltage Phase AB
77. STRT BC V – Starter Voltage Phase BC
78. STRT CA V – Starter Voltage Phase CA
79. STRT AVG V – Starter Average Phase Voltage
80. STRT AMPS L1 – Starter Current L1
81. STRT AMPS L2 – Starter Current L2
82. STRT AMPS L3 – Starter Current L3
83. STRT AVG AMP – Average Line Current – Amps
84. STRT I L1 PC – Starter Current L1 % RLA
85. STRT I L2 PC – Starter Current L2 % RLA
86. STRT I L3 PC – Starter Current L3 % RLA
87. STRT AVG PCT – Average Line Current % RLA
88. POWER – Starter Power Consumption
89. PF – Starter Load Power Factor
90. INBOARD BEAR – Inboard Bearing Temperature
91. OTBOARD BEAR – Outboard bearing Temperature
92. W1 TEMP – Motor Winding Temperature #1
93. W2 TEMP – Motor Winding temperature #2
94. W3 TEMP – Motor Winding Temperature #3
95. FREQUENCY – Frequency
96. TRANS TMP – AFD Transistor Temperature
97. START STOP – BAS Chiller Auto Stop Command
98. MODE COMD – BAS Chiller Mode Command
99. STPT – BAS Chilled Water Setpoint
100. BAS C LMT SP – BAS Current Limit Setpoint
101. BAS HW SP – BAS Hot Water Setpoint
102. BAS LOAD STP – BAS Base Loading Setpoint
103. BAS LOAD ENB – BAS Base Loading Enable
104. DIAG RESET – BAS Diagnostic Reset

JJ. Finish:

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

   a. Provide at least one (1) coat of primer with a total dry film thickness of at least two (2) mils.
   b. Provide at least two (2) coats of alkyd modified, vinyl enamel finish with a total dry film thickness of at least four (4) mils.
   c. Paint surfaces that are to be insulated before applying the insulation.
   d. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

KK. Accessories:

1. Pressure Differential Switches (PDS):

a. General Requirements: Chiller manufacturer shall provide pressure differential devices for field installation on each chiller. The pressure differential switches shall be rated for a minimum operating pressure if 150 psi with the delta 'P' for the evaporator and condensed shells at the mid range of the switch. The pressure range shall be from '0' to a value above the unit rated pressure drop. See example below:

1) Pressure Range Example:

a) Evaporator PD – 10 ft. Range: 0 ft - 20 ft.
b) Condenser PD – 25 ft. Range: 0 ft. – 50 ft.

b. Switch Manufacturers: The switches indicated below are being used on the UMB Campus. Chiller manufacturer shall select PDS switches from one (1) of the following:

1) Orange Research Inc.: Series 1516
2) Dwyer: Duotect Series H3
3) United Electric Controls: Series J21K

c. Specific Requirements:

1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
2) Performance: Switch shall withstand, without damage, the full pressure rating of the heat exchanger applied to either port and exhibit zero set point shift due to variation in working pressure.
3) Set Point: Screw type, field adjustable.
4) Electrical Connections: Internally mounted screw type terminal blocks.
5) Switch Enclosure: NEMA 250, Type 4.
6) Switch Action: Double-pole, double throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.

LL. Vibration Isolation:

1. Slab on Grade Installation Only:

a. Neoprene Pad: Provide two (2) layers of one (1) inch thick, ribbed or waffle-pattern neoprene pads separated by a 16 gauge, stainless-steel plate.

2. Penthouse Slab Installation:

    a. For requirements see Division 23 Specification Section "Vibration and Seismic Controls for HVAC."

MM. Noise Rating: [85] <Insert dBA> sound power level when measured according to ARI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

NN. Source Quality Control

1. For chillers using R-134a refrigerant, factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.
2. <Retain first paragraph below for chillers using R-123 refrigerant.>
3. For chillers using R-123 refrigerant, factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 01. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig (310 kPa). Vacuum and pressure test for leaks.
4. For chillers located indoors, rate sound power level according to ARI 575.
5. Each chiller shall be factory performance tested at twenty-five (25), fifty (50), seventy-five (75), and one hundred (100) percent, in an ARI certified test facility in accordance with ARI certified criteria. The manufacturer shall supply an ARI certified test report to confirm performance as specified. Test results shall meet or exceed performance efficiencies as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer for inspection. The performance test shall be conducted in accordance with ARI Standard 550-92 procedures and tolerances.
6. Stable operation at a minimum load of 10% shall be demonstrated during the factory performance test with constant entering condenser water temperature. The machine shall be modified to include hot gas bypass if the minimum load cannot be demonstrated.
7. Additional Performance Test: In addition to the standard ARI test perform an additional performance test using a constant $85^0$F/$95^0$F condenser water temperature from 100% loading through 10% part loading. Submit both standard and additional ARI test results to A/E and UMB.
8. Submitted chiller performance shall include an ARI approved selection method for the specified refrigerants. Verification of date and version of computer program selection or catalog shall be provided.
9. The performance test shall be run with clean tubes in accordance with ARI 550-92 to include the following:

    a. A downward temperature adjustment 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 shall be made to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.
c. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments in paragraphs 'a' and 'b'. The manufacturer shall clean tubes, if necessary, prior to test to obtain a test fouling factor of 0.0000 hr. sq. ft. ºF/BTU.

10. 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).
11. The owner or his representative shall be notified twenty eight (28) days in advance to witness the factory performance test. A travel allowance of two thousand five hundred dollars and no cents ($2,500.00) total shall be included in the bid price as an allowance for the chillers for owner representative(s) to witness the factory performance test. The travel allowance shall only be used to pay for transportation, lodging, meals, and associated costs for the owner's designated representative(s) (not to be used for costs associated with factory or manufacturer's representatives or for testing costs).<Delete if not applicable to particular project.>
12. A certified test report of all data shall be submitted to UMB prior to completion of the project. 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.

## 2.3 OXYGEN MONITOR

A. Provide an approved oxygen monitor for any chiller that utilizes an A1 refrigerant as follows:

1. Delta F Corporation, Series 500
2. INTEC Controls QCW-500
3. Alternate sensors shall be submitted for approval using the specified substitution requirement process prior to bid and shall meet the following criteria:

a. Sensor to be nondepleting coulometric or electro chemical cell with a warranty of five (5) years.
b. Monitor to be digital with a 0% to 25% range and an accuracy of plus or minus 1% of full scale.
c. Response time to be thirty (30 seconds for a 90% response.
d. Monitor shall include two (2) fully adjustable setpoints, an instrument condition alarm relay, and a voltage or current output signal.

## 2.4 REFRIGERANT MONITOR

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Trane True Sense MG Monitor: Model RMWE – Basis of Design
2. Chillgard Refrigerant Monitors; MSA; Instrument Division.
3. Haloguard Monitors; Thermal Gas Systems, Inc.

B. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, [shutting down fuel-fired equipment,] and automatically activating ventilation system. <Edit for project>

C. ASHRAE: Monitoring system shall comply with ASHRAE 15.

D. Performance:

1. Refrigerant to Be Monitored: HCFC 123, HFC – 134a. <Edit for Project>
2. Range: 0 to 1,000 ppm.
3. Sensitivity:

a. Minimum Detectability: One (1) ppm.
b. Repeatability: +/- 1% of full scale.
c. Response time in first subparagraph below shall increase with number of air sampling points and if more than one hundred fifty (150) feet of air sampling tubing is used to any single point.
d. Response: Maximum ten (10) seconds per sample.

1) Detection Level 1: 50 ppm.
2) Detection Level 2: 250 ppm.

4. Operating Temperature: $32^0$F to $104^0$F.
5. Relative Humidity: 20% to 95%, noncondensing over the operating temperature range. Compensate sensor for relative humidity.

E. Input/Output Features:

1. Maximum Power Input: 120-V ac, 60 Hz, 75 W.
2. Number of Air-Sampling Points: <Insert number>.
3. Air Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.
4. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.
5. Alarm Relays: Minimum three (3) relays at a minimum of five (5) A resistive load each.

6. Alarm Set Points: Displayed and adjustable through keypad on front of meter.
7. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.
8. Alarm Manual Reset: Momentary contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.
9. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.
10. Audible Output: Minimum 75 dB at ten (10) feet.
11. Visible Output: Strobe light.
12. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.
13. Serial Output: RS-232 or RS-485 compatible with HVAC controls.
14. Enclosure: NEMA 250, Type 1 with locking quarter turn latch and key.
15. BAS Connections: Provide PPM and alarms to BAS.

F. Monitor Alarm Sequence:

1. Detection Level One (1): Notify the BAS control workstation of the detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Run ventilation system at high speed on a rise in concentration to this level, and change to low speed on a reduction in concentration below this level. Operate the ventilation system at high speed for a minimum of five (5) minutes. Cycle amber strobe lights.
2. Detection Level Two (2): Notify the BAS control workstation of the detection in the refrigeration equipment room on a rise of refrigerant concentration to this level. Terminate operation of any combustion process equipment located in the refrigeration equipment room. Provide manual reset for this detection level.
3. Sensor Fault/Trouble: Notify the BAS control workstation of fault/trouble detection in monitor.

G. Notification Appliances:

1. Horns: Comply with UL 464; electric vibrating polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille. Horns shall produce a sound pressure level of 90 dBA, measured ten (10) feet from the horn.
2. Visible Alarm Devices: Comply with UL 1971; three (3) color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "REFRIGERANT DETECTION" printed in minimum one and one half (1/2) inch high letters on the lens. Rated light output is seventy five (75) candela.
3. Location: Provide horns and strobes at each door to the mechanical equipment room where the chillers are located.

H. Air Sampling Tubing:

1. Annealed Temper Copper Tubing: ASTM B 88, Type L.
2. Polyethylene Tubing: ASTM D 2737, flame-retardant, nonmetallic tubing rated for ambient temperature range of $10^0$F to $150^0$F.

## 2.5 PACKAGED AIR COOLED WATER CHILLERS <Delete if not required for Project>

A. Description: Factory assembled and run tested water chiller complete with base and frame, condenser casing, scroll compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories. Reciprocating compressors will not be acceptable.

B. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure. <Delete if not seismic requirements>

C. Cabinet:

1. Base: Galvanized steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single piece unit.
2. Frame: Rigid galvanized steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
3. Casing: Galvanized steel.
4. Finish: Coat base, frame, and casing with a corrosion resistant coating capable of withstanding a five hundred (500) hour salt spray test according to ASTM B 117.
5. Sound reduction package consisting of the following:

    a. Acoustic enclosure around compressors.
    b. Reduced speed fans with acoustic treatment.
    c. Designed to reduce sound level without affecting performance.

6. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access. <Delete if not required>

D. Scroll Compressors: <Edit for Project.>

1. Description: Each compressor shall be positive displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
3. Operating Speed: Nominal 3,600 rpm for 60-Hz applications.
4. Capacity Control: Provide "On/Off" compressor cycling [, plus hot gas bypass].
5. Oil Lubrication System: Include automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

6. Vibration Isolation: Mount individual compressors on vibration isolators.

E. Compressor Motors:

1. Compressor motors shall be hermetically sealed and cooled by refrigerant suction gas.
2. Motors shall be high torque, two (2) pole induction type with inherent thermal overload protection on each phase.

F. Compressor Motor Controllers:

1. Across the Line: Controllers shall be NEMA ICS 2, Class A full voltage, nonreversing type.

G. Refrigeration:

1. Refrigerant: Refrigerant shall be R-410a which is classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include a thermal expansion valve, refrigerant charging connections, a hot gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable core filter dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Refrigerant Isolation: Factory installed positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

H. Evaporator:

1. Brazed Plate:

a. Direct-expansion, single-pass, brazed-plate design.
b. Type 316 stainless-steel construction.
c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

2. Shell and Tube:

a. Description: Shell and tube evaporator shall be designed and constructed with tubes mounted within the shell to allow chilled water to flow through the shell and refrigerant to flow through the tubes.

b. Code Compliance: Prior to shipment the entire assembly shall be tested and stamped according to ASME Boiler and Pressure Vessel Code.
c. Shell Material: Shell shall be constructed of Carbon steel.
d. Shell Heads: Removable carbon steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
e. Shell Nozzles: Shell fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

3. Electric Heater: Heater shall be, electric type, factory installed and wired with integral controls to protect the evaporator to - 20°F.

I. Air Cooled Condenser:

1. Air cooled condenser shall be a plate fin coil with integral subcooling on each circuit, rated at 450 psig.

a. Construct coils of copper tubes mechanically bonded to aluminum fins.
b. Coat coils with a baked epoxy corrosion resistant coating after fabrication.
c. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

2. Fans: Fans shall be direct drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

3. Fan Motors: Fan Motors shall be one of the following:

a. Totally enclosed nonventilating (TENV) enclosure.
b. Totally enclosed air over (TEAO) enclosure.

4. Bearings: Fan bearings shall be permanently lubricated type bearings.
5. Motor Protection: Fan motors shall have built in overcurrent and thermal overload protection.
6. Fan Guards: Steel safety guards with corrosion-resistant coating.

J. Electrical Power: <Edit for Project.>

1. Single Point Power Connection: Provide factory installed and wired switches, motor controllers, transformers, and other electrical devices necessary for a single point field power connection to water chiller.
2. Enclosure: Provide a unit-mounted, NEMA 250, [Type 3R] <Insert type> enclosure with hinged access door with lock and key or padlock and key.

3. Wiring Identification: Wiring shall be numbered and color-coded to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field power interface shall be to NEMA KS 1, heavy duty, fused disconnect switch.
6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

    a. NEMA KS 1, heavy duty, fusible switch with rejection type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    b. NEMA KS 1, heavy duty, nonfusible switch.
    c. NEMA AB 1, motor circuit protector (circuit breaker) with field adjustable, short circuit trip coordinated with motor locked rotor amperes.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
9. Phase Failure and Undervoltage: Solid state sensing with adjustable settings.
10. Provide power factor correction capacitors to correct power factor to 0.90 at full load.
11. Transformer: Provide unit mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

    a. Power unit mounted controls.
    b. Power unit mounted, ground fault interrupt (GFI) duplex receptacle.

12. Control Relays: Include auxiliary and adjustable time delay relays for internal safety and controls.
13. Indicate the following for water chiller electrical power supply for display on the LED display on the control panel:

    a. Current, phase to phase, for all three (3) phases.
    b. Voltage, phase to phase and phase to neutral for all three phases.
    c. Three phase real power (kilowatts).
    d. Three phase reactive power (kilovolt amperes reactive).

14. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

    a. Low evaporator pressure or high condenser pressure.
    b. Low chilled water temperature.
    c. Refrigerant high pressure.
    d. High or low oil pressure.
    e. High oil temperature.
    f. Loss of chilled water flow.

g. Control device failure.

K. Insulation:

1. Material: Closed cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
2. Thickness: Three quarter (3/4) inch.
3. Factory applied insulation over cold surfaces of water chiller components.

a. Adhesive: As recommended by insulation manufacturer and applied to 100% of insulation contact surface. Seal seams and joints.

4. Apply protective coating to exposed surfaces of insulation.

L. Accessories:

1. Differential Pressure Switch: Provide a differential pressure switch for field installation in the chilled water piping.
2. Compressor Accessories: Include individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
3. Vibration Control: Vibration isolation devices and flexible connectors for pipe and power connections shall be provided by the mechanical contractor.

M. Capacities and Characteristics: <Delete paragraph if scheduled on drawings>

1. Noise Rating: <Insert dBA> at <Insert distance in feet> when measured according to ARI 370.

## PART 3 - EXECUTION

### 3.1 CHILLER INSTALLATION

A. Install chillers on support structure where indicated on the drawings.

B. Equipment Mounting:

1. Install chillers on cast in place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Architectural Specification Section's "Cast in Place Concrete." and/or "Miscellaneous Cast in Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Division 23 Specification Section "Vibration and Seismic Controls for HVAC Systems."

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

D. Charge chiller with refrigerant and fill with oil if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Division 23 Specification Section "HVAC Piping Systems and Specialties," Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage and drain connection with valve. Make connections to chiller with a mechanical coupling.

D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, flexible connector, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, and drain connection with valve. Make connections to chiller with a mechanical coupling.

E. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend separate vent piping for each chiller to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. For chillers equipped with a purge system, extend separate purge vent piping for each chiller to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.

G. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run in period.
6. Check bearing lubrication and oil levels.

7. Verify that refrigerant pressure relief device is vented outside.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

## 3.4 REFRIGERANT MONITORING SYSTEM INSTALLATION

A. Comply with ASHRAE 15 and ASHRAE 147.

B. Install air sampling inlets, or diffusion type monitors in pits, tunnels, or trenches in machinery room that are accessible to personnel.

C. Floor mount diffusion type monitor, sensor/transmitters, or air sampling inlets on slotted channel frame twelve (12) inches to eighteen (18) inches above the floor in a location near the refrigerant source or between the refrigerant source and the ventilation duct inlet.

D. Wall mount air sampling, multiple point monitors with top of unit sixty (60) inches above finished floor.

E. Run air sampling tubing from monitor to air sampling point, in size as required by monitor manufacturer. Install tubing with maximum unsupported length of thirty six (36) inches, for tubing exposed to view. Terminate air sampling tubing at sampling point with filter recommended by monitor manufacturer.

F. Install air sampling tubing with sufficient slack and flexible connections to allow for vibration of tubing and movement of equipment.

G. Purge air sampling tubing with dry, oil free compressed air before connecting to monitor.

H. Number code or color code air sampling tubing for future identification and service of air sampling multiple point monitors.

I. Extend air sampling tubing from exhaust part of multiple point monitors to outside.

J. Install warning signs, labels, and nameplates to identify detection devices according to Division 23 Specification Section "Identification for HVAC Systems and Equipment."

K. Place warning signs inside and outside each door to the refrigeration equipment room. Sample wording: "AUDIBLE AND VISUAL ALARM SOUNDING INDICATES REFRIGERANT DETECTION - ENTRY REQUIRES SELF-CONTAINED BREATHING APPARATUS."

L. Audible Alarm Indicating Devices: Install at each entry door to refrigeration equipment room, and position not less than six (6) inches below the ceiling. Install horns on flush mounted back boxes with the device operating mechanism concealed behind a grille.

M. Visible Alarm-Indicating Devices: Install adjacent to each audible alarm indicating device at each entry door to refrigeration equipment room, and position at least six (6) inches below the ceiling.

N. Field Quality Control:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
3. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

O. Tests and Inspections:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties.
3. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

P. Repair or replace malfunctioning units and retest as specified above.

END OF SECTION 236416