PART 1 - GENERAL REQUIREMENTS

1.01 SECTION INCLUDES

A. Chiller Package.

B. Charge of refrigerant.

C. Controls and control connections.

D. Chilled water connections.

E. Variable speed drives.

F. Electrical power connections.

1.02 REFERENCE STANDARDS

A. AHRI 550/590 - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle; 2011.

B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.

C. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.

D. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.

E. IEEE 519 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems; 2014.

F. NEMA MG 1 - Motors and Generators; 2014.

G. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc; Current Edition, Including All Revisions.

H. UL 465 – Central Cooling Air Conditioners.

I. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.03 SUBMITTALS

A. Reference Division 01 for general submittal procedures.

B. Product Data: Provide rated capacities, minimum and maximum chilled water flows, weights (shipping, installed, and operating), specialties and accessories and electrical requirements. Submit manufacturer’s ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed. Provide short circuit current rating of factory mounted starter or variable frequency drive.

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. Manufacturer's Certificate: Certify that components of package not furnished by manufacturer have been selected in accordance with manufacturer's requirements.

E. Test Reports: Indicate energy input versus cooling load output from 0 to 100 percent of full load at specified and minimum condenser water temperature.

F. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.

G. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.

H. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories. Include trouble- shooting guide.

I. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

J. Submit certification of compliance with ASME, UL, AND ASHRAE fabrication requirements specified in “Reference Standards” above.

K. Submit certification of compliance with performance verification requirements specified in “Reference Standards” above.

L. Submit field quality control reports specified in PART 3 of this Section.

M. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Reference Division 01 for additional provisions.
2. Extra Refrigerant: One container.
3. Extra Lubricating Oil: One container.

1.04 QUALITY ASSURANCE:

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

B. Provide certification of inspection in compliance with the requirements of Authority Having Jurisdiction.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

D. Machine Experience: At time of submission of bid or proposal, chiller model proposed must have acquired minimum of 2 years experience on each of 10 field installations, each machine having acquired minimum of 2,400 operating hours.

1.05 DELIVERY, STORAGE, AND HANDLING

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

B. Handle chillers and components properly to prevent damage, breaking, denting and scoring. Do not install damaged reciprocating chillers or components; replace with new. Comply with manufacturer's rigging and installation instructions for unloading chillers, and transporting them to final location.

C. Store chiller and components in clean dry space. Protect from weather, dirt, fumes, water, construction debris, and physical damage. Storage temperatures for unit controls are not to exceed 185 deg. F.

1.06 WARRANTY

A. Reference Division 01 for additional warranty requirements.

B. Manufacturer's Special Warranty on Compressor Bearings: Written parts and labor warranty, signed by manufacturer agreeing to repair or replace compressor bearings and related damage including replacement of refrigerant, and including tear down for bearing inspection in the fifth year of operation.

1. Warranty Period: Manufacturer's standard, but not less than five years after date of Substantial Completion.

C. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Arctic

B. Multi-Stack

C. Smardt

D. Trane.

2.02 CHILLERS

A. Chillers: Factory assembled and tested, packaged, water cooled, hermetic or open type centrifugal chillers consisting of centrifugal compressors, compressor motors, condenser, evaporator, refrigeration accessories, instrument and control panel including gauges and indicating lights, auxiliary components and accessories, and motor starters. Provide with standard factory-finish.

B. Rating: Comply with AHRI 550/590.

C. Safety: Comply with UL 1995.

D. Comply with ASME BPVC-VIII-1 for construction and testing of centrifugal chillers.

E. Comply with ASHRAE Std 15 for safe construction and operation of centrifugal chillers.

2.03 MAGNETIC BEARING COMPRESSOR

A. General: Compressor shall be a single or multi-stage centrifugal type powered by a high speed, direct drive electric motor.

B. Compressor Casing: Fine grain cast aluminum designed for working pressure of refrigerant and hydrostatically tested to 1.5 times the working pressure.

C. Impellers: Single or multi-stage, in-line design, fully shrouded, cast high strength aluminum alloy, statically and dynamically balanced and overspeed tested for smooth, vibration free operation, designed and assembled for no critical speeds within operating range, mounted on heat treated forged or rolled steel shaft, nonferrous, labyrinth seals between stages.

D. Compressor Motor: Motor shall be a hermetic, oil free, permanent magnet type directly coupled to the compressor. The motor shall be bolted to a cast iron adapter plate mounted on the compressor to provide factory alignment of the shaft.

E. Bearings: The motor shaft shall be supported on active magnetic radial and thrust bearings. Magnetic bearing control shall be equipped with auto vibration reduction and balancing systems. During a power failure event, the magnetic bearings shall remain active throughout the compressor coast down to enable the drive train to come to a controlled, safe stop. If needed, rolling element bearings shall be provided as a backup to the magnetic bearings designed for emergency touch down situations.

F. Variable Speed Drive (VSD): Variable speed drive shall be factory installed on the chiller. Refer to Paragraph “Variable Speed Drive” for requirements.

2.04 EVAPORATOR

A. Provide evaporator of shell and tube type, seamless or welded steel, seamless copper tubes with integral individually replaceable fins, rolled or silver brazed into tube sheets. Position intermediate tube support sheets along length of shell to avoid contact and relative motion between adjacent tubes. Tubes shall be removable from

either end of the heat exchanger without affecting the strength and durability of the tube sheets and without causing leakage in adjacent tubes.

B. Hydronic Piping Connections: Integral to the water heads with flanged or grooved connections.

C. Test and, where applicable, stamp refrigerant side for 150 psig working pressure and water side for working pressure as scheduled on the drawings, in accordance with ASME BPVC-VIII-1.

D. Provide thermometer wells or thermistors for temperature controller and low temperature cutout. Provide suitable tappings for control sensors and gauges.

E. Design and construct evaporator to prevent liquid refrigerant from entering the compressor.

F. Provide carbon rupture disc or relief valve on shell in accordance with ASHRAE Std 15.

G. Provide pressure limiting devices in accordance with ASHRAE Std 15.

H. Construction and materials to comply with ASME BPVC-VIII-1 or ASHRAE Std 15 as applicable to chiller manufacturer and chiller model.

2.05 CONDENSERS

A. Provide condensers of shell and tube type, seamless or welded steel construction with fabricated steel heads, seamless copper tubes with integral fins, rolled or silver brazed into tube sheets. Position intermediate tube support sheets along shell length to avoid contact and relative motion between adjacent tubes. Tubes shall be removable from either end of the heat exchanger without affecting the strength and durability of the tube sheets and without causing leakage in adjacent tubes.

B. Hydronic Pipe Connections: Integral to the water heads with flanged or grooved connections.

C. Test and, where applicable, stamp refrigerant side for 150 psig working pressure and water side for working pressure as scheduled on the drawings; in accordance with ASME BPVC-VIII-1.

D. Provide carbon rupture disc or relief valve on shell in accordance with ASHRAE Std 15.

E. Provide pressure limiting devices in accordance with ASHRAE Std 15.

F. Provide baffles to ensure even distribution of incoming gas and to concentrate non-condensable gases.

G. Construction and materials to comply with ASME BPVC-VIII-1.

2.06 PURGE SYSTEM

A. Provide purge system on positive pressure units, incorporating a low temperature refrigeration system to automatically remove non-condensable gases, water and air, and for condensing, separating, and returning refrigerant to the system.

B. Provide all necessary devices to automatically isolate purge system from chiller.

C. System discharge shall be maximum 0.60 pound of refrigerant per pound of air discharged.

2.07 CONTROLS

A. Disconnect Switch: As indicated on the drawings.

B. Flow Switch: Furnish field-mounted differential pressure sensor or thermal dispersion flow switch (paddle-type flow switch not allowed)

C. Refrigerant Flow Control Devices:

1. Provide refrigerant flow control devices between evaporator and condensers (and elsewhere as required) to regulate refrigerant flow at volume and pressure required to maintain evaporator liquid refrigerant at level sufficient to keep cooler heat transfer tubes adequately wetted through full range of chiller operation.
2. Design devices to permit chiller operation at scheduled conditions, and to allow condenser entering water temperature to decrease to minimum permissible temperature or 1 deg. F above return chilled water temperature.

D. Capacity Control:

1. Designed and fabricated to regulate evaporator leaving water temperature. Design for capacity modulation, from full load to scheduled minimum load capacity under normal operating conditions, without overshooting and without hunting at scheduled throttling range.

E. Safeties and diagnostics:

1. Provide electronic overloads and indicating light, current fault protection and indication light, power failure indication light, high temperature protection and indication light, transient voltage protection insensitive to input phase sequence, phase loss protection, diagnostic test switches, and hinged access doors with key lock.

F. Provide microprocessor-based control panel, factory-mounted and wired, containing solid state, fully automatic operating and safety controls. Provide proportional integral derivative (PID) control strategies. Provide operator interface that accesses chiller information and control adjustments at the face of the control panel.

G. Provide communications port to communicate with the building management system with BACNet or LONWorks compatible interface for chiller monitoring, control and data gathering. Coordinate with the building controls contractor the exact building management system requirements.

H. Provide electrical interlock to prevent chiller operation when chilled water pump(s) and/or condenser water pump(s) are not operating.

I. Provide the following manufacturer's standard safety controls, including the following minimum functions, so that operating any one will shut down machine and require manual reset:

1. Low evaporator refrigerant temperature.
2. High condenser refrigerant pressure.
3. Low refrigerant (evaporator) pressure.
4. High compressor discharge temperature.
5. Low evaporator leaving water temperature (freeze-stat).
6. High motor temperature.
7. High bearing temperature.
8. Compressor motor overcurrent or over voltage.
9. Power interruption.

J. Include anti-recycle timer, factory wired to control panel, limiting compressor motor restarts at time intervals as recommended by manufacturer.

K. Provide the manufacturer's standard safety controls arranged so that operating any one will shut down machine and automatically reset.

L. Provide a diagnostic module capable of indicating all lockout conditions specified above, plus recording the elapsed time (pre-alarm to alarm), the operating conditions of the compressor motor (amperes), refrigerant temperatures and pressures, and chilled and condenser water temperatures (entering and leaving) at the time of lockout.

M. Provide the following devices on control panel:

1. Manual Switches:

a) Machine off-auto switch.
b) Machine selector switch to allow load, unload, hold or automatic operation.

2. Manual Set Point Adjustments:

a) Leaving chilled water temperature.
b) Current demand limit.

3. Status Lights:

a) Chilled water flow proven.
b) Cooling required.
c) Unit running.
d) Unit loading.
e) Unit unloading.
f) Manual reset required.
g) Remote chilled water set point active.
h) Remote current water set point active.

4. Setpoint and Temperature Display:

a) Chilled water set point.
b) Current limit set point.
c) Entering evaporator water temperature.
d) Leaving evaporator water temperature.
e) Entering condenser water temperature.
f) Leaving condenser water temperature.

5. Dial Type Pressure Gauges:

a) Evaporator refrigerant pressure.
b) Condenser refrigerant pressure.

c) Low oil pressure (oil sump).
d) High oil pressure (oil supply).

N. Provide the following operating controls:

1. Solid state, chilled water temperature controller that controls electronic guide vane operator. Locate temperature sensor in entering chilled water.
2. Adjustable thirty minute off timer prevents compressor from short cycling.
3. Automatic start that determines demand for chilled water from proof of chilled water flow and temperature differential between chilled water set point and supply temperature.
4. Solenoid valve between heat recovery condenser and receiver to limit refrigerant level in condenser.
5. Provide controls to ensure that compressor will start only under unloaded condition.
6. Provide sequencing controls to ensure lubrication of compressor motor bearings and seals (if any). Sequence as follows:

   a) Run lubrication system oil so that compressor motor bearing is lubricated before start-up,
   b) Start compressor motor,
   c) Provide lubrication during coast-down after compressor motor shut-down.

7. Provide modular electronic, solid state, or pneumatic controls.
8. Design controls to automatically restart compressor after power failure interruptions, provided minimum time between starts has been complied with.

2.08 SOUND

A. Maximum Permissible Sound Pressure Level (SPL): Use 0.0002 microbar as reference. SPL measurements shall be taken in multiple directions that uniformly cover 360 degrees. Measurements shall be taken at a distance from the unit as specified in the applicable AHRI Standard. Unit shall be operating at full load under standard AHRI ambient and water temperature conditions and within the installation parameters set forth by the applicable AHRI Standard.

B. Do not exceed the maximum permissible dB level in any of the following octave bands:

Sound, dB	63Hz	25Hz	250Hz	.5kHz	1kHz	2kHz	4kHz	8kHz	LwA
Power	-72	77	69	65	61	61	57	56	69

2.09 VIBRATION ISOLATION:

A. Provide devices of type and size recommended by chiller manufacturer and as required in Division 23 Section “Vibration Isolation for HVAC.”

2.010 VARIABLE SPEED DRIVE (VSD), UNIT MOUNTED

A. Furnish chiller with factory-mounted, liquid-cooled variable speed drive (VSD) shipped completely factory-assembled, wired, and tested.

B. Specifically design VSD to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. VSD control logic is to optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If surge is detected, VSD surge avoidance logic is to make adjustments to move away from and avoid surge at similar conditions in the future.

C. VSD Efficiency: 97 percent or better at full speed and full load.

D. Fundamental Displacement Power Factor: Minimum of 0.96.

E. Provide voltage and current regulated, solid state, microprocessor-based pulse-width modulated (PWM) VSD. Output power devices to be IGBT transistors.

F. Provide liquid-cooled heatsink to cool the power semi-conductor and capacitor.

G. Provide cleanable shell and tube heat exchanger with water-cooled design. Do not provide plate and frame heat exchanger.

H. Furnish VSD in a NEMA Type 1 metal enclosure having a minimum short circuit withstand rating of 65,000 amps per UL 508. 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.

1. Enclosure to include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.
2. Entire chiller package to be listed by Underwriter's Laboratories Inc.

I. VSD to be tested according to UL 508 and listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.

J. Comply with recommendations stated in IEEE 519.

1. Include integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than or equal to 5 percent as measured at the VSD input. If active filters are used to meet this requirement, then the losses associated with the filter are to be included in the chiller performance on the selection.

K. Fundamental Displacement Power Factor: Minimum of 0.96.

L. Voltage Input: Nominal 480 volts, three phase, 60 hertz AC, plus or minus 10 percent of nominal voltage.

M. Line Frequency: 38 to 60 hertz.

N. VSD to include the following:

1. All control circuit voltages physically and electrically isolated from power circuit voltage.
2. 150 percent instantaneous torque available for improved surge control.
3. Soft start, adjustable linear acceleration, coast-to-stop.
4. Adjustable current limiting and UL approved electronic motor overload protection.
5. Insensitivity to incoming power phase sequence.
6. VSD and motor protection from the following faults:

a) Output line-to-line short circuit.
b) Line-to-ground short circuit.
c) Phase loss at AFD input.
d) Phase reversal/imbalance.
e) Over-voltage.
f) Under-voltage.
g) Over-temperature.

O. Include the following VSD status indicators available to facilitate startup and maintenance:

1. Output speed in hertz and rpm.
2. Input line voltage.
3. Input line kW.
4. Output/load amps.

5. Average current in percent RLA.
6. Load power factor.
7. Fault.
8. VSD transistor temperature.

P. Service Conditions (at full output power; no external venting or heat exchangers required):

1. Operating Ambient Temperature: Between 32 degrees F and 104 degrees F.
2. Room Ambient Relative Humidity: Up to 95 percent.
3. Elevation: Up to 3,300 feet. For every 300 feet above 3,300 feet, decrease the rated output current by one percent.

Q.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s installation instructions.

B. Provide for connection to electrical service.

C. Refer to Division 26 Sections for wiring devices, wires and cables, and electrical installation requirements.

D. Install and connect remote flow switches.

E. Ground equipment.

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

F. Provide for connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit.

G. Align chiller on concrete foundations, sole plates, and sub-bases. Level, grout, and bolt in place.

H. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.

I. Install vibration isolators to concrete pad with anchor bolts and secure chiller to vibration isolators.

J. Maintain manufacturer's recommended clearances for servicing and maintenance.

K. Install chiller accessories which have been shipped loose or unassembled for shipment purposes.

L. Piping installation requirements are specified in other sections of Division 23. The Drawings indicate the general arrangement of piping, fittings, and specialties.

M. Install piping adjacent to machine to allow servicing and maintenance.

N. Provide flanged or grooved evaporator connections to chilled water piping with accessories as indicated in the details on the drawings.

O. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.

P. Insulate evaporator and cold surfaces.

Q. Provide flanged or grooved condenser connections to condenser water piping with accessories as indicated in the details on the drawings. Arrange piping to allow removal of condenser heads.

R. Arrange piping for easy dismantling to permit tube cleaning.

S. Provide piping from chiller rupture disc to outdoors. Size as recommended by manufacturer.

T. Provide drain piping as indicated from rupture disc or relief valve to suitable drain.

U. Provide the services, to include a written report, of a factory authorized service representative to supervise the field assembly of the components, installation, and piping and electrical connections

3.02 SYSTEM STARTUP

A. Provide services of factory trained representative for minimum of one day to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, and calibrate controls.

B. Supply initial charge of refrigerant and oil.

C. Demonstrate system operation and verify specified performance. Refer to Section 23 05 93 Testing Adjusting and Balancing.

D. Evacuate, dehydrate, vacuum pump and charge with specified refrigerant, and leak test in accordance with manufacturer's instructions. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

E. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.

F. Do not place chillers in sustained operation prior to initial balancing of mechanical systems for interface with chillers.

3.03 CLOSEOUT ACTIVITIES

A. Train operating personnel in operation and maintenance of units.

B. Provide the services of the manufacturer's field representative to conduct training.

C. At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of eight hours on the operation and maintenance of the equipment provided under this section.

D. Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

E. Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

F. Schedule training with Owner with at least 7 days' advance notice.

3.04 MAINTENANCE

A. Provide a separate maintenance contract for specified maintenance service.

B. Furnish service and maintenance of complete assembly for one year from Date of Substantial Completion.

END OF SECTION