

# ATTACHMENT A

ARCHITECT/ENGINEER SIGNATURE PAGE



OKLAHOMA CERTIFICATE OF AUTHORIZATION  
P.E. #1072  
EXPIRES 06/30/2024

SECTION 017823  
OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

A. Description

1. Compile product data, training materials, and related information appropriate for Owner's maintenance and operation of products furnished under the contract.
  - a. Prepare operating and maintenance data as specified in this section and as referenced in other pertinent sections of the Invitation to Bid (ITB).
2. Instruct Owner's personnel in the maintenance and operation of equipment and systems furnished under the contract. Reference Section H below.

B. Related Work Specified Elsewhere

1. Centrifugal Water Chillers: Section 236416.

C. Quality Assurance

1. Preparation of data shall be done by personnel:
  - a. Trained and experienced in maintenance and operation of the described products.
  - b. Completely familiar with requirements of this Section.
  - c. Skilled as a technical writer to the extent required to communicate essential data.
  - d. Skilled as a draftsman competent to prepare required drawings.

D. Data Manuals

1. Prepare data in the form of an instructional manual for use by Owner's personnel. Provide digital PDF and hard-bound copies as specified herein.
2. Format:
  - a. Test: Manufacturer's printed data.
  - b. Drawings:
    - (1) Provide reinforced and neatly bound, bind in with test.
    - (2) Fold larger drawings to the size of the test pages.

- c. Provide flyleaf for each separate product, or each piece of operating equipment.
  - (1) Provide typed description of product, and major component parts of equipment.
  - (2) Provide indexed tabs.
- d. Cover: Identify each volume with typed or printed title "OPERATING AND MAINTENANCE INSTRUCTIONS".
 

List:

  - (1) Title of Project.
  - (2) Identity of separate structure as applicable.
  - (3) Identity of general subject matter covered in the manual.

3. Binders:

- a. Commercial quality three-ring binders with durable and cleanable plastic covers.
- b. If multiple binders are used, collate the data into related consistent groupings.

E. Content of Manual

- 1. Manual shall include copies of all final approved corrected shop drawings, product data, performance summaries, descriptive brochures, and parts lists for each major component.
- 2. Neatly typewritten table of contents of each volume, arranged in a systematic order.
  - a. General Contractor, name of responsible principal, address, and telephone number.
  - b. A list of each product required to be included, indexed to the content of the volume.
  - c. List, with each product, the name, address, and telephone number of:
    - (1) Installing Contractor.
    - (2) Suggested maintenance contractors, as appropriate.
    - (3) Identify the area of responsibility of each.
    - (4) Local source of supply for parts and replacement.

- d. Identify each product by product name and other identifying symbols as set forth in ITB.
- 3. Product Data:
  - a. Include only those sheets which are pertinent to the specific product.
  - b. Annotate each sheet to:
    - (1) Clearly identify the specific product or part installed.
    - (2) Clearly identify the data applicable to the installation.
    - (3) Delete references to inapplicable information.
- 4. Drawings:
  - a. All final approved general arrangement drawings, shop drawings, P&IDs, and wiring diagrams.
  - b. Coordinate drawings with information in approved submittals to assure correct illustration of completed installation.
- 5. Written text, as required to supplement product data for the particular installation.
  - a. Organize in a consistent format under separate headings for different procedures.
  - b. Provide a logical sequence of instructions for each procedure.
- 6. Copy of each warranty, bond, and service contract issued.
  - a. Provide information sheet for Owner's personnel, give:
    - (1) Proper procedures in the event of failure.
    - (2) Instances which might affect the validity of warranties or bonds.

F. Manual for Equipment and Systems

- 1. Content, for each unit of equipment and system, as appropriate:
  - a. Description of unit and component parts.
    - (1) Function, normal operating characteristics, and limiting conditions.
    - (2) Performance curves, engineering data, and tests.
    - (3) Complete nomenclature and commercial number of all replaceable parts.



- b. Operating Procedures:
    - (1) Start-up, break-in, routine, and normal operating instructions.
    - (2) Regulation, control, stopping, shut-down, and emergency instructions.
    - (3) Summer and winter operating instructions.
    - (4) Special operating instructions.
  - c. Maintenance Procedures:
    - (1) Routine operations.
    - (2) Guide to "troubleshooting".
    - (3) Disassembly, repair, and reassembly.
    - (4) Alignment, adjusting, and checking.
  - d. Servicing and lubrication schedule with list of lubricants required.
  - e. Manufacturer's printed operating and maintenance instructions.
  - f. Original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
    - (1) Predicted life of parts subject to wear.
    - (2) Items recommended to be stocked as critical spare parts.
  - g. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
  - h. Other data as required under pertinent sections of specifications.
2. Content, for each electric and electronic system, as appropriate:
- a. Description of system and component parts.
    - (1) Function, normal operating characteristics, and limiting conditions.
    - (2) Performance curves, engineering data, and tests results.
    - (3) Complete nomenclature and commercial number of replaceable parts.
  - b. As-installed color-coded wiring diagrams.

- c. Operating Procedures:
    - (1) Routine operations.
    - (2) Guide to "troubleshooting".
    - (3) Disassembly, repair, and reassembly.
    - (4) Adjustment and checking.
  - d. Manufacturer's printed operating and maintenance instructions.
  - e. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
  - f. Other data as required under pertinent sections of specifications.
3. Prepare and include additional data when the need for such data becomes apparent during instruction of Owner's personnel.

G. Submittal Schedule

- 1. Submit 1 digital copy of preliminary draft of proposed formats and outlines of contents prior to start of work. Owner and Architect-Engineer will review draft and return with comments.
- 2. Submit 1 digital and 2 hard copies of completed data in final form fifteen days prior to final inspection or acceptance. Copy will be returned after final inspection or acceptance, with comments.
- 3. Submit 1 digital and 2 hard copies of approved data in final form 10 days after final inspection or acceptance.

H. Instruction of Owner's Personnel

- 1. Prior to final inspection or acceptance, fully instruct Owner's designated operating and maintenance personnel in the proper and optimized operation, adjustment, and maintenance of the centrifugal water chillers and all furnished components as specified in Section 236416.
- 2. Training sessions specified herein are subject to video recording for future reference by Owner's operations personnel.
- 3. Operating and maintenance manual shall constitute the basis of instruction.
  - a. Review contents of manual with Owner's operations personnel in full detail to explain all aspects of operations and maintenance.

4. Provide a minimum of 20 normal working hours (four shifts, minimum five hours per shift) of on-site classroom instruction and hands-on field training at the installed equipment. Coordinate all instruction with the Owner.

END OF SECTION

SECTION 236416  
CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. The Seller shall furnish in accordance with the requirements of the Invitation to Bid (ITB) two (2) packaged centrifugal water chillers each complete with dual refrigeration compressors, free-standing medium voltage variable frequency drives, complete chiller control package, and all other accessories and appurtenances as specified herein. The chiller and all accessories specified herein shall be new and built in accordance with a successful quality control program.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. kW/Ton : The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- C. NPLV.IP: Non-standard part-load value. A single-number part-load efficiency rating for a single chiller calculated according to the method defined by AHRI 550/590 (2020) and intended for operating conditions other than the AHRI 550/590 standard rating conditions.
- D. SCCR: Short-circuit current rating.
- E. VFD: Variable frequency drive.

1.3 SUBMITTALS

- A. Seller shall submit the required documents and materials in accordance with the ITB and as specified herein within 60 days of receipt of purchase order from Owner. Shop drawings, catalog data, bill of material, brochures, etc. shall include manufacturer's name, model number, service, type of equipment, and specific location of where installed, dimensions, capacities, and performance curves on all equipment.
- B. All submittals shall be submitted in electronic PDF format.
- C. All numerical data shall be submitted in engineering I-P units.
- D. Product Data: For each chiller.
  - 1. Include refrigerant type, rated capacities, operating characteristics, and furnished specialties and accessories.
  - 2. Minimum and maximum evaporator water flow rate.
  - 3. Minimum and maximum condenser water flow rate.
  - 4. Refrigerant capacity of chiller at rated conditions.

5. Oil capacity of chiller.
  6. Fluid capacity of evaporator and condenser.
  7. Characteristics of refrigerant pressure relief devices.
  8. Minimum entering condenser water temperature at full design condenser water flow and specified design evaporator conditions.
  9. Summary of predicted performance data points in kW/Ton from 100% load down to 30% load in 10% increments at entering condenser water temperatures ranging from 85°F down to 55°F in 5°F increments. Performance calculations shall assume evaporator water flow is variable while evaporator water temperatures are held constant at the specified design conditions and condenser water flow is constant.
- E. All shop drawings shall be drawn to scale on 11" x 17" sheets as specified herein. Seller shall submit, as a minimum, the following shop drawings and submittals for each chiller:
1. Water Chillers:
    - a. General arrangement
    - b. Foundation requirements including corner weights (anchor loads)
    - c. Customer connections
    - d. Compressors
    - e. Evaporator and condenser shells
    - f. Interconnecting piping and power wiring
    - g. Chilled water and condenser water instrumentation and control diagrams
    - h. Refrigeration system instrumentation and control diagrams
    - i. Include plans, elevations, sections, details, and attachments to other work
  2. Refrigerant Recovery Unit (Bid Option #1):
    - a. General arrangement
    - b. Foundation requirements including corner weights (anchor loads)
    - c. Customer connections
    - d. Interconnecting piping and power wiring
    - e. Include plans, elevations, sections, details, and attachments to other work
- F. Submit complete performance data and manufacturer's data for the following as a minimum:
1. Lubrication system
  2. Control Panel
    - a. Device arrangements
    - b. Electrical diagrams
  3. Motor starters for auxiliary equipment (where applicable)
  4. Circuit breaker test reports
  5. Compressor Motor(s):
    - a. Connection diagram
    - b. Thermal limit curve
    - c. Time vs. speed curve
    - d. Terminal box
    - e. Coupling and guard

6. Compressor Motor Outline Drawing:
  - a. Complete physical dimensions and weight
  - b. Location and size of all terminal boxes and complete terminal layout
  - c. Location and size of all lube oil and cooling water piping connections with temperature and GPM requirements (where applicable)
  - d. Location and size of all grounding pads
  - e. Master drawing list of all motor submittals
7. Motor Nameplate Drawing
8. Motor Terminal Box Drawing

G. Submit the following main induction motor performance data for each chiller:

1. All performance data required as part of the submittal shall be supplied in a formal submittal for the actual motor being furnished.
2. Motor torque curves in lb. ft. versus motor speed in RPM at 42.3%, 65%, and 100% voltage.
3. Motor torque and driven equipment torque curves in lb. ft. versus motor and driven equipment speed in RPM.
4. Motor acceleration time curves in sections versus motor speed in RPM for 42.3%, 65% and 100% voltage.
5. Operating current curves in amperes versus time in seconds at rated output torque for 42.3%, 65%, and 100% voltage.
6. Motor current curve in amperes versus time in seconds for thermal damage.

H. Submit the following data for VFDs:

1. Mechanical layout of all components showing dimensions and clearances.
2. Electrical layout showing all connections and functions of both power and control circuits and electrical specifications of components.
3. Time current curves indicating coordinated protective relay settings plotted with motor time current characteristics.
4. Tables indicating available settings on all protective relays.
5. Tables indicating suggested settings of all protective relays and devices.
6. Wiring diagrams.
7. Interconnection diagrams.

#### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include emergency, operation, and maintenance manuals in accordance with Section 017823, OPERATION AND MAINTENANCE DATA. The manual for each chiller shall include but not be limited to the following:

1. A copy of all final approved corrected shop drawings, equipment submittals, control diagrams, descriptive brochures, and a parts list for each major component of the chiller package.

2. A complete and detailed set of operating and maintenance instructions including the charging, start-up, control or sequencing of operation, phase or seasonal variations, shut-down, safety, and similar operational instructions pertaining to the water chiller, compressor motors, motor controllers, chiller controls, and all accessories and associated equipment.
  3. A complete description of each unit of the control system and its relationship with the functioning of the entire control system, a complete set of control system hookup drawings, ladder-type wiring diagrams for interlock and control wiring, and descriptive literature on each instrument incorporated in the system, and a comprehensive troubleshooting guideline.
  4. Detailed oil lubrication data for all equipment.
- B. Field inspection and startup service reports, including written confirmation that chillers and associated components have been installed by the Installing Contractor in accordance with the manufacturer's recommendations.

## 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
  2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
  3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
  4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.
- B. Touch-up Paint: 32-oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

## 1.6 BID OPTIONS

- A. Bid Option #1 - Packaged Refrigerant Recovery Unit
1. Furnish, in accordance with the requirements of the ITB, one (1) packaged refrigerant recovery unit designed to store the full refrigerant charge of one (1) of the proposed 4,000 Ton chillers. Unit shall consist of a refrigerant compressor or vacuum pump, with oil separator, storage receiver, receiver pressure relief device(s), heater, air-cooled condenser, filter drier, and necessary valves and hoses to remove, replace, and distill refrigerant.
  2. Storage Vessel: Horizontal type with three or more view ports installed to check liquid level. The receiver shall be designed and stamped in accordance with the ASME Boiler and Pressure Vessel Code. Pitch vessel toward the receiver drain to allow total removal of liquid.
  3. Refrigerant Compressor:
    - a. For medium pressure units provide a reciprocating compressor that is capable of pulling a vacuum to a minimum level of 23 inches Hg in the chillers.

4. Refrigerant Vacuum Pump:
    - a. For low pressure units provide a vacuum pump to achieve the vacuum levels required by the EPA.
  5. Condenser: Air-cooled and permanently mounted with refrigerant lines piped to the system.
  6. Accessories:
    - a. Oil separator with electric heater.
    - b. High-pressure switch to protect the receiver and compressor against over pressurization in accordance with ASME specifications.
    - c. Float switch to cut unit off when tank is 80% full of liquid refrigerant.
    - d. Filter Drier: Permanently mounted, replaceable core type, capable of removing moisture to less than 50 ppm.
    - e. Three or more liquid level view ports on storage vessel.
    - f. Pressure gauges mounted on suction and discharge side of storage vessel.
  7. Unit shall include a means for automatically providing an accurate measurement of and indicating the weight of refrigerant in the storage tank.
- B. Bid Option #2 – Chiller Spring Isolation Mounts
1. Furnish chiller manufacturer's spring isolation mounts in lieu of standard neoprene vibration isolation pads for each chiller.
- C. Bid Option #3 – Extended Warranty
1. Seller's bid proposal shall include an extended parts and labor five (5) year warranty for chiller items specified below furnished under this ITB. The proposal shall clearly identify all components covered by the extended warranty, the conditions of the warranty, and the maximum response time (not greater than 48 hours) associated with Owner identified warranty items. Include end-of-warranty inspection for items covered by extended warranty. The requirements of Paragraph 1.11 apply to Bid Option #3.
    - a. Refrigeration compressors
    - b. Complete compressor and drive assembly
    - c. Induction drive motors
    - d. Variable frequency drives
    - e. Refrigerant and lubrication oil: Loss of refrigerant or oil for any reason due to manufacturer product defect and product installation during warranty period.

## 1.7 QUALITY ASSURANCE

- A. Safety: Comply with ANSI/ASHRAE Standard 15-2019, Safety Standard for Refrigeration Systems
- B. UL Labels: Furnish chiller electrical components which have been listed and labeled by Underwriters' Laboratories.



- C. NEMA Compliance: Comply with applicable portions of National Electrical Manufacturers Association Standards pertaining to chiller motors and motor energy management.
- D. Standards for Design, Fabrication, and Installation: Except as otherwise indicated, comply with the following:
  - 1. ASME Boiler and Pressure Vessel Code, Section VIII. Provide ASME stamp on chiller showing compliance with ASME Code.
  - 2. ANSI B31.1, Power Piping Code.
  - 3. National Electrical Code (NFPA 70).
- E. Comply with applicable portions of the 2018 International Mechanical Code.

#### 1.8 EQUIPMENT SOUND LEVELS

- A. Chiller sound pressure level in the near field, as defined by AHRI Standard 575-2008, shall not exceed 85 dB(A) for each machine.
- B. All sound pressure data shall be obtained and recorded in accordance with AHRI Standard 575- 2008 and shall include, but not be limited to sound pressure levels in dB re. 0.0002 microbar at 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz as well as the equivalent dB(A) sound pressure level.
- C. All sound pressure level data shall be submitted on certified data forms from the manufacturer.
- D. Maximum Noise Rating: 85 dB(A) equivalent sound power level at full load conditions when measured according to AHRI Standard 575-2008. Provide factory-installed sound treatment if necessary to achieve required performance.

#### 1.9 MANUFACTURER

- A. Packaged centrifugal water chillers shall be the standard manufactured product of one of the manufacturers listed below meeting all the requirements of the ITB.

Trane

York

#### 1.10 DELIVERY, STORAGE, AND HANDLING

- A. The Seller shall ship and deliver the centrifugal water chillers and all furnished components as specified herein to the Installing Contractor who shall receive the chillers and components, unload the chillers and components, and install the chillers and components. The Seller shall, within four weeks of date of receipt of purchase order, begin preliminary coordination for the shipping and delivery of all chillers with both the Owner. If by this time an Installing Contractor has yet to be selected or awarded the installation contract, detailed instructions for receiving, rigging, and unloading shall be provided to the Owner for incorporation into forthcoming construction documents to be furnished to the Installing Contractor at a later date. All shipping costs, required permits, and method of shipment shall be the responsibility of the Seller and shall be included in the Bid Price.

- B. Seller shall provide the Owner with maximum wheel loads and required clearances for the shipping vehicle with chiller no less than eight (8) weeks prior to shipment of the chillers.
- C. Multi-Piece Assemblies: If required, disassemble chillers into major components including the evaporator barrels, the condenser barrels, compressor(s), and motor-drive assemblies as required for shipment and installation by Installing Contractor.
  - 1. Chiller assembly or disassembled components must fit through a 16 feet wide by 16 feet tall overhead door opening.
- D. Seller shall coordinate the manufacturer of all chillers and associated components with the Owner and Installing Contractor's construction schedule for sufficient manufacturing time and delivery of all chillers and associated components so that product storage time at either the chiller manufacturing facility or at the job site is minimized. Any product storage shall be included in this project at no additional cost to the Owner.
- E. Charge each chiller's refrigeration system including compressors, evaporator shell, and condenser shell with dry nitrogen prior to shipping of components.

#### 1.11 WARRANTY

- A. Furnish twelve (12) months equipment parts and labor warranty for each centrifugal water chiller and all parts and accessories furnished under this ITB. Warranty period shall start on date of chiller installation substantial completion issued by the Owner or six (6) months after each chiller arrives to and is assembled at the jobsite, whichever occurs first. Furnish and install any refrigerant or oil charge lost for any reason due to manufacturer product defect and product installation during warranty period. Substantial completion of a chiller is defined herein as seven (7) consecutive days of operation without issue after factory startup and acceptance by the Owner.
- B. Seller shall provide an on-site end-of-warranty material and operating inspection for each chiller and all associated controls and components furnished under this ITB. Inspections shall be coordinated with the Owner and shall be scheduled to start not earlier than 28 calendar days prior to expiration date of the chiller 12 month warranty period and completed with a written report submitted not later than 7 days prior to the warranty expiration date. The Seller's inspector(s) shall be qualified chiller manufacturer's service representative(s) and field engineer(s) and shall observe and inspect the material condition and operation of all chillers and components in company with the Owner's operating and maintenance personnel. The Seller's inspector(s) shall document in writing all observed material and operating conditions constituting a warranty item. In addition, material and operating conditions identified by the Owner's operating and maintenance personnel as warranty items shall be included. The Seller shall provide the Owner with a comprehensive list of warranty items and his proposed timing for correcting all documented items.
- C. All warranty items that are reported by the Owner require not greater than a 48-hour response time from the equipment manufacturer's authorized representative.

## PART 2 - PRODUCTS

### 2.1 DESCRIPTION

- A. Furnish two (2) centrifugal water chillers in accordance with the requirements of the ITB. Each chiller shall include but not be limited to the following:
1. Centrifugal compressors, evaporator, condenser, drive motors, and all required refrigerant piping, valves, and auxiliary components.
  2. Compressor drive motors with free-standing variable frequency drives (VFDs)
  3. Microprocessor unit control panel.
  4. Initial charge of refrigerant and oil, shipped in separate containers.
  5. Manufacturer's special tool kit complete with special and non-standard tools required for servicing chiller.
  6. Services of a manufacturer's installation and start-up technician.
  7. All motor starters and disconnects for all auxiliary motors.
  8. All sensors and wiring required by the microprocessor.
  9. All chiller electric motors and VFDs shall be designed for continuous operation at 40°C ambient temperature.
  10. All microprocessor and electronic components shall be designed for continuous operation at 40°C ambient temperature.
  11. All chiller auxiliary motors 1/2 HP and larger, except main drive motor, shall be 460 volt, 3 phase. All auxiliary motors less than 1/2 HP shall be 110 volts, single phase.
  12. Auxiliary chiller motors shall be as manufactured by Delco Division GMC, TECO-Westinghouse, Siemens Allis, Inc., U.S. Electric Motors Division, General Electric, Lincoln, or Baldor.
  13. Each chiller shall be furnished with marine water boxes on both the evaporator and condenser. Provide lifting lugs on all marine water boxes. Provide hinged end plates on all marine water boxes to permit each end plate to swing open for access to marine water box interior. Heat exchangers with a two-pass design shall include hinged end shell cover at the end of each chiller shell opposite the end with the marine water box. Furnish vents and drains with removable plugs on all water boxes.
  14. Each chiller shall be certified by the manufacturer to safely operate without surge at 15% load with AHRI 550-590 entering condenser water at design conditions. Furnish hot gas bypass if required to meet this requirement.
  15. Furnish permanently attached metal nameplate containing the following information as a minimum:
    - a. Manufacturer's name, serial number, model number, date of manufacture, location of manufacture.
    - b. Design cooling capacity in Tons and refrigerant type.
    - c. Design chilled water flow in GPM, design entering and leaving chilled water temperature in degrees F, design evaporator water pressure drop in PSIG.
    - d. Design condenser water flow in GPM, design entering and leaving condenser water temperature in degrees F, design condenser water pressure drop in PSIG.

16. All temperature and pressure sensors and transmitters required for each chiller's microprocessor control panel shall either be factory installed or furnished by the Seller for installation by the Installing Contractor. The Seller shall furnish all required chilled water and condenser water flow switches and signal transmitters for installation by the Installing Contractor. Flow switches shall be thermal dispersion type; paddle type is not acceptable. Seller shall furnish the Installing Contractor with all required electrical schematics, wiring diagrams, and technical data necessary to ensure complete operating systems.
17. Furnish each centrifugal water chiller with chiller manufacturer's standard molded neoprene vibration isolation pads. Two or more layers of ribbed- or waffle-pattern neoprene bonded to steel plate.

## 2.2 PERFORMANCE REQUIREMENTS

- A. Two (2) centrifugal water chillers shall each conform to the following rating requirements and design conditions:
  1. Refrigeration System:
 

|                                 |               |
|---------------------------------|---------------|
| a. Guaranteed Capacity          | 4,000 Tons    |
| b. Minimum Full Load Efficiency | 0.6100 kW/Ton |
| c. Minimum NPLV/IP Efficiency   | 0.3800 kW/Ton |
  2. Evaporator:
 

|                                |                                     |
|--------------------------------|-------------------------------------|
| a. Entering Water Temp.        | 54.0 °F                             |
| b. Leaving Water Temp.         | 42.0 °F                             |
| c. Maximum Water Pressure Drop | 22.0 ft.wc.                         |
| d. Maximum Nozzle Size         | 20 inch                             |
| e. Fouling Factor              | 0.000100 ft <sup>2</sup> -°F-hr/Btu |
  3. Condenser:
 

|                                |                                     |
|--------------------------------|-------------------------------------|
| a. Entering Water Temp.        | 85.0 °F                             |
| b. Leaving Water Temp.         | 95.0 °F                             |
| c. Maximum Water Pressure Drop | 28.0 ft.wc.                         |
| d. Maximum Nozzle Size         | 24 inch                             |
| e. Fouling Factor              | 0.000250 ft <sup>2</sup> -°F-hr/Btu |
  4. Compressor Electrical Requirements:
 

|          |           |
|----------|-----------|
| a. Volts | 4,160 VAC |
| b. Phase | 3         |
| c. Hertz | 60        |
- B. Performance Optimization: Design characteristics of the proposed chiller shall be optimized for variable evaporator flow operation and a chiller plant control strategy that maintains the lowest feasible entering condenser water temperature in order to minimize compressor lift while maintaining stable chiller operation.
- C. Performance Tolerance: Comply with requirements of AHRI 550/590 (2020).

- D. ASHRAE Compliance:
  - 1. ASHRAE Standard 15-2019 for safety code for mechanical refrigeration.
  - 2. ASHRAE Standard 147-2019 for refrigerant leaks, recovery, handling, and storage requirements.
- 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-513A refrigerant, include an ASME U-stamp and nameplate certifying compliance.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Comply with requirements of Underwriters Laboratories Inc. and include label by a qualified testing agency showing compliance.

## 2.3 COMPRESSOR-DRIVE ASSEMBLY

- A. Description: Single-stage or multi-stage, variable- or dynamic-displacement, centrifugal-type compressor driven by an electric motor.
  - 1. Provide each compressor with a dedicated motor and motor controller.
  - 2. Provide controls and isolation valves for continued operation when a compressor-drive assembly fails.
- B. Compressor:
  - 1. Casing: Cast iron, precision ground.
  - 2. Impeller: High-strength cast-aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.
- C. Drive: Direct- or gear-drive, open or hermetic design, using an electric induction type motor as the driver.
  - 1. Gear Drives:
    - a. For chillers with oil-lubricated gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating.
    - b. Gears shall comply with American Gear Manufacturer Association standards.
  - 2. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication. Provide calculations for motor heat dissipated to the space.
  - 3. Seals: Seal drive assembly to prevent refrigerant leakage.
- D. Compressor Motor:
  - 1. Continuous-duty, squirrel-cage, induction-type, two-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 each of three-phase motor windings 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.
  7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
  8. Provide a vibration sensor to detect vibration of the shaft in the compressor drive assembly. Report values to chiller control panel with alarm when vibration levels exceed manufacturer's tolerances.
  9. Provide a large steel terminal box with gasketed front access cover for field connected conduit.
  10. Provide overload/overcurrent transformers.
- E. 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. Overspeed Test: At least 20 percent above design operating speed.
  2. Vibration Limits: Velocities not to exceed 0.15 inches/sand 0.8 mils peak to peak on all axes.
- F. Service: Readily accessible for inspection and 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.
- G. Capacity Control: 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 15 percent of design capacity without surge in operation.
  3. Chiller VFD shall modulate compressor speed with variable-inlet, guide-vane control, or similar technology, to achieve optimum energy efficiency. When multiple compressors are furnished, provide a separate VFD for each motor-drive assembly.
- H. Oil Lubrication System: Consisting of pump, filtration, heater, cooler, factory-wired power connection, and controls.
1. Bearings, gears, and other rotating surfaces shall be lubricated at all operating, startup, coast down, and standby conditions, including power failure.
  2. Provide immersion oil heaters that are thermostatically controlled to remove refrigerant from the oil.
  3. Dual oil filters, one redundant, or two (2) oil filters at 50% capacity shall be the easily replaceable cartridge type, with a maximum beta ratio of 1,000 at 2.5 micron particle size. Provide means of positive isolation while servicing.

4. Refrigerant-cooled oil cooler.
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. Thermostatically controlled oil heater.

## 2.4 REFRIGERATION

- A. Refrigerant (one of the following):
  1. Type: R-1233zd
  2. Type: R-513a
- B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying specified performance requirements.
- C. Pressure Relief Device:
  1. The evaporator and condenser shall have relief devices sized in accordance with requirements in ASHRAE Standard 15-2019, ASHRAE Standard 147-2019, and applicable portions of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
  2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
  3. Where dual pressure relief devices are installed in series, provide a sensor with indicator between devices to indicate refrigerant release past first device.
  4. For Chillers Operating at Sub-Atmosphere Conditions: Rupture disc constructed of frangible carbon and spring-loaded, pressure relief valve; single- or multiple-reseating type.
  5. For Chillers Operating at Above-Atmosphere Conditions: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
- D. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant recovery unit. Comply with requirements in ASHRAE Standard 15-2019 and ASHRAE Standard 147-2019.
- E. Refrigerant Isolation for Chillers Using R-1233zd and R-513a:
  1. 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.
  2. Suction side of compressor from evaporator shall have an isolation valve to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.

F. Purge System:

1. For chillers operating at sub-atmospheric pressures, factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of non-condensables including but not limited to liquid water, water vapor, and other non-condensable gases.
2. System shall be of thermal purge design, refrigerant- or air-cooled, and 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 non-corrodible materials.
5. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
6. Efficiency of not more than 0.02 lb of refrigerant per pound of air when rated according to AHRI 580.
7. Operation independent of chiller according to ASHRAE Standard 147-2019.

G. Vacuum Prevention System:

1. For chillers operating at sub-atmospheric pressures, factory install an automatic vacuum prevention system.
2. During non-operational periods, 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 but not be limited to a controller, electric heat, pressure transmitter or transducer, and a solid-state safety circuit.

## 2.5 EVAPORATOR AND CONDENSER

- A. Description: Shell-and-tube design with water in tubes, in a one-pass or two-pass arrangement, and refrigerant surrounding tubes within shell. The refrigerant side of each evaporator and condenser shell shall be designed, tested, and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII - Division I. The water side of the evaporator and condenser shall be designed for 150 psig design working pressure and tested at 225 psig.
- B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
- C. Designed to prevent liquid refrigerant carryover from entering compressor.
- D. Evaporator and condenser shall have sight glass or other form of positive visual verification of liquid-refrigerant level in each barrel.
- E. Tubes:
1. Individually replaceable from either end 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: Minimum 3/4 inch or as required for specified performance.



5. Minimum Wall Thickness: 0.025 inch.
  6. External Finish: Manufacturer's standard.
  7. Internal Finish: Enhanced.
- F. 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.
- G. 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, but not more than 4 ft. apart.
- H. Water Boxes: Designed for 150 psig design working pressure and tested at 225 psig.
1. Marine type, with piping connections, carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  2. Provide hinged water-box covers with lifting lugs or eyebolts.
  3. Nozzle Pipe Connections: Welded, ASME B16.5, raised-face flange.
  4. Nozzle Piping Connection Locations – One Pass Design:
    - a. Evaporator Inlet – left/front (left side, into chiller from front)
    - b. Evaporator Outlet – right/front (right side, out from chiller towards front)
    - c. Condenser Inlet – right/top (right side, into chiller from top)
    - d. Condenser Outlet – left/top (left side, out from chiller towards top)
  5. Nozzle Piping Connection Locations – Two Pass Design:
    - a. Evaporator Inlet – left/front (left side, into chiller from front)
    - b. Evaporator Outlet – left/top (left side, out from chiller towards top)
    - c. Condenser Inlet – left/rear (left side, into chiller from rear)
    - d. Condenser Outlet – left/top (left side, out from chiller towards top)
  6. RTD temperature sensor factory installed in each nozzle.
  7. Fit each water box with 3/4-inch drain connection at low point and vent connection at high point, each with threaded plug.
- I. Flow Switches:
1. Factory installed in water box piping nozzle by chiller manufacturer or furnished loose by chiller manufacturer for field installation by Installing Contractor. Provide a switch for each evaporator and condenser. Switches shall be thermal dispersion type. Paddle-type flow switches shall not be allowed.
  2. Thermal Dispersion Switches:
    - a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
    - b. Performance: Switch shall withstand, without damage, the full-pressure rating of the chiller applied to either port and exhibit zero set-point shift due to variation in working pressure.
    - c. Set Point: Magnet type, field adjustable.
    - d. Setpoint Range: 0.5 to 10 fps.
    - e. Repeatability: 0.07 fps +3% of setpoint.
    - f. Maximum Working Pressure: 300 psig.

- g. Electrical Connections: Internally mounted screw-type terminal blocks.
  - h. Switch Enclosure: NEMA 250, Type 4X.
  - i. Switch Action: One normally open NPN and one normally closed NPN switch, with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
- J. Tube Sheet and Water Box Corrosion Protection:
- 1. Provide a factory-applied ceramic alloy coating to interior side of evaporator and condenser water boxes and tube sheets. Coating shall be "CeramAlloy CL+AC" by Enecon Corporation or "1321 (Ceramic S-Metal)" by Belzona. Coating shall be applied per manufacturer's recommendations.

## 2.6 INSULATION

- A. Flexible elastomeric closed-cell foam thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- 1. Minimum Thickness: 3/4 inch.
  - 2. Maximum Thermal Conductivity, 75 °F Mean Temp: 0.25 Btu-in/hr-ft<sup>2</sup>-°F
- B. Adhesive: As recommended by insulation manufacturer.
- C. Factory-applied insulation over all surfaces of chiller capable of forming condensation when operating in an ambient environment with a 75°F dew point temperature. Components shall include but not be limited to evaporator shell and end tube sheets, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant economizer (where applicable), refrigerant-cooled motor, and auxiliary piping.
- 1. Apply adhesive to 100 percent of insulation contact surface.
  - 2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
  - 3. Seal seams and joints to provide a continuous vapor barrier.
  - 4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
- D. Evaporator marine water boxes and nozzles will be field insulated by the Owner's Installing Contractor.

## 2.7 ELECTRICAL

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

## 2.8 VARIABLE FREQUENCY DRIVE (VFD)

- A. The variable frequency drive shall be remote floor mounted. VFD shall vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part-load efficiency by analyzing information fed to it by sensors located throughout the chiller.
  - 1. VFDs shall not be provided with any form of direct on-line starting system.
- B. Description: NEMA ICS 2; listed and labeled according to UL 508 as a complete unit.
- C. The VFD shall consist of the following components:
  - 1. Incoming Disconnect, one per drive assembly.
  - 2. Where recommended by the manufacturer, one 24-pulse input isolation transformer per drive assembly, with rectifier that limits electrical power supply distortion.
  - 3. Frequency Converter/Inverter
  - 4. VFD Protective System/Devices
  - 5. Output filter or reactor (when required to limit reflected voltage)
- D. Integral Disconnecting Means: The VFD shall include a main disconnect device with an interlocked and padlockable handle mechanism. The disconnecting device shall be a medium voltage vacuum contactor with a bolted pressure disconnect switch whose blades are externally visible from outside the enclosure. The disconnect device shall have a momentary withstand rating greater than the available fault current indicated on the Manufacturer's Data Sheet. When multiple doors are supplied, all doors shall be electrically interlocked with the disconnect device. The interlocks shall include provisions to manually override for test and repair.
- E. Input Power Transformer and Rectifier (when required): The VFD shall contain an incoming isolation transformer whose primary voltage shall be 4,160 V.
  - 1. The transformer shall contain 12 three phase secondary windings that provide the proper phase shifting to develop a 24-pulse rectification to reduce harmonic currents and voltages reflected to the primary power system.
  - 2. The transformer shall be copper wound and shall have a 220 °C insulation system to operate at 115 °C rise at full load conditions.
  - 3. The transformer and rectifier shall be an integral part of the VFD assembly along with primary disconnects switch, input vacuum contactor and secondary fusing eliminating the need for separate components field installation or wiring.
  - 4. Soft charge of the DC bus capacitors is accomplished by use of an input reactor on the primary of the input transformer. A vacuum contactor rated for drive full load amps will short the reactor after charge is accomplished.
- F. Power Requirements:
  - 1. VFD shall be capable of providing rated output for continuous voltage deviations of +10%.
  - 2. Input short circuit withstand rating shall be 50,000A.
  - 3. VFD shall be able to ride through voltage dips down to 10% of minimum, such as those experienced during motor starting.

4. VFD 40 second overload current rating shall be set at 105% of rated compressor current. Comply with the requirements of IEEE 519 -1992 for total harmonic input current and voltage distortion measurement and calculation.
  - a. Voltage distortion shall not exceed 3% and current distortion shall not exceed 5% at the input lugs of the VFD over an operating power range of 30% to 100% of rated power with phase voltage imbalance per the 3% specification.
- G. VFD converter section shall be configured as a 24-pulse or greater to eliminate the need for harmonic filters.
- H. The VFD inverter section shall consist of three cells where each cell has two series DC power supplies per phase. Each DC supply is derived from a phase shifted secondary of the input transformer that cancels reflected harmonics back to the power line. The DC power supply is filtered by long lasting oil filled capacitors.
  1. Each cell shall have 3,300 V Insulated Gate Bipolar Transistors (IGBT's), quantity as determined by the manufacturer, in a single-phase bridge connection such that when in combination with the other bridges, a 5 level output voltage is constructed to the motor. A bridge neutral point shall be jumpered to each of the three cells. This configuration called Neutral Point Clamp (NPC) provides a normal phase to ground level voltages.
  2. Each power device shall communicate to the microprocessor with fiber optic communications.
  3. A high resistance ground detection circuit at the neutral point shall be used for system shutdowns in the event the load has a ground fault.
  4. Two Hall Effect Current Transformers (HCT) shall be used for current feedback on the VFD output.
  5. PWM firing pulses shall result in an output voltage and current waveform that will result in less than 2% torque ripple over a 20 to 1 speed range on the motor.
- I. Door-interlocked, NEMA AB1, instantaneous-trip circuit breaker with lockable handle. Minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system but not less than 100,000 A.
- J. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors; suitable for variable torque loads.
- K. Output Rating: Three phase, with voltage proportional to frequency throughout voltage range.
- L. Operating Requirements:
  1. Input AC Voltage Tolerance: Input isolation transformer output voltage, plus 10 percent.
  2. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
  3. Capable of driving full load, without derating, under the following conditions:
    - a. Ambient Temperature: Up to 40 °C.
    - b. Relative Humidity: Up to 90 percent (non-condensing).
    - c. Altitude: Up to 3,300 feet.

4. Minimum Efficiency: 97.0 percent at 60 Hz, full load.
  5. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter; 98 percent with harmonic filter.
  6. Overload Capability: 1.05 times the full-load current for seven seconds.
  7. Starting Torque: As required by compressor-drive assembly.
  8. Speed Regulation: Plus or minus 1 percent.
  9. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
  10. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
  11. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- M. Internal Adjustability Capabilities: Integral to controller or through chiller control panel.
1. Minimum Output Frequency: 6 Hz.
  2. Maximum Output Frequency: 60 Hz.
  3. Acceleration: Two seconds to a minimum of 60 seconds.
  4. Deceleration: Two seconds to a minimum of 60 seconds.
  5. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.
- N. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
1. Over-temperature.
  2. Short circuit at controller output.
  3. Ground fault at controller output. Variable frequency drive shall be able to start a grounded motor.
  4. Open circuit at controller output.
  5. Input undervoltage.
  6. Input overvoltage.
  7. Loss of input phase.
  8. Reverse phase.
  9. AC line switching transients.
  10. Instantaneous overload, line to line or line to ground.
- O. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- P. Automatic Reset and Restart:
1. Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
  2. Controller shall be capable of automatic restart on phase-loss and overvoltage and under-voltage trips.
- Q. Visual Indication: Through chiller control center indicating the following conditions:
1. Power on.
  2. Run.
  3. Motor speed (percent).
  4. Motor output voltage.

5. Input kilovolt amperes.
6. Input kilowatts.
7. Three-phase input voltage.
8. Three-phase output voltage.
9. Three-phase output current.

R. Operator Interface: All operator controls and adjustments shall be through the Chiller control center. The VFD shall include necessary components to protect the VFD and motor against motor overload, internal faults in either the motor or VFD and disturbances in the incoming AC line. The following conditions shall cause the VFD to be shut down with the output voltage reduced to zero. The failure shall be annunciated on the Chiller control center.

1. Cooling fan loss
2. Input transformer over temperature
3. Heatsink over temperature
4. Motor current overload
5. Output current imbalance
6. High output frequency
7. Input phase loss
8. DC Link Voltage imbalance
9. DC Link Voltage overvoltage
10. DC Link Voltage undervoltage
11. Ground fault
12. Power supply fault
13. IGBT gate drive fault
14. Communications fault
15. Cabinet doors interlock

S. Control Signal Interface: VFDs shall communicate with the chiller control center via a communication link.

T. Cooling: Air cooled; designed for reliable operation at 40 °C ambient temperature.

U. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Control Relays: Auxiliary and adjustable time-delay relays.

## 2.9 CHILLER CONTROLS

- A. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory, so that reprogramming is not required upon loss of electrical power.
- B. Enclosure: Unit mounted, NEMA 250, Type 1, hinged or lockable, factory wired with a single-point, with field-power connection and a separate control circuit.
- C. Factory-installed wiring outside of enclosures shall be in a NFPA 70-approved raceway.

D. Operator Interface: HMI color touchscreen display with dynamic update of information on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

1. Date and time.
2. Operating or alarm status.
3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.
6. Operating hours.
7. Number of chiller starts.
8. Entering- and leaving-fluid temperatures of evaporator and condenser.
9. Difference in fluid temperatures of evaporator and condenser.
10. Refrigerant pressures in evaporator and condenser.
11. Refrigerant saturation temperature in evaporator and condenser shell.
12. Compressor refrigerant suction and discharge temperature.
13. Compressor bearing temperature.
14. Motor bearing temperature.
15. Motor winding temperature.
16. Oil temperature.
17. Oil discharge pressure.
18. Phase current.
19. Percentage of motor-rated load amperage.
20. Phase voltage.
21. Demand power (kilowatts).
22. Energy use (kilowatt-hours).
23. Power factor.
24. For variable frequency drives include the following:
  - a. Output voltage and frequency.
  - b. Voltage THD for each phase.
  - c. Supply current TDD for each phase.
  - d. Inlet vane position.
  - e. Controller internal ambient temperature.
  - f. Heatsink temperature.
25. Purge suction temperature if purge system is provided.
26. Purge elapsed time if purge system is provided.

E. 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.
3. Current limit and demand limit.
4. Condenser-fluid temperature.
5. External chiller emergency stop.

F. 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-1233zd refrigerant.
- G. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
- H. Security Access: Provide electronic security access to controls through identification and password, with at least three levels of access: view only; view and operate; and view, operate, and service.
- I. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
- J. Communication Port: RS-232 port, USB2.0 port or higher, or equivalent connection capable of connecting a printer and a notebook computer.
- K. BAS Interface: Factory install hardware and software to enable system to monitor, control, and display chiller status and alarms.
1. Hardwired I/O Points:
    - a. Monitoring: Compressor running status (BO), latching alarm relay (BO), purge system alarm relay (BO).
    - b. Control: Remote enable/disable (BI), remote emergency stop (BI), evaporator leaving water temperature setpoint (AI), condenser head pressure control (AO), evaporator pump control (BO), condenser pump control (BO)
  2. Communication Interface: ASHRAE Standard 135 compliant BACnet MS/TP communication interface shall enable control system operator to remotely control and monitor the chiller from an operator workstation.
    - a. Control features and monitoring points displayed locally at chiller control panel shall be available through the control system, including the following as a minimum:
      - 1) Enable/disable command from remote source.
      - 2) Chiller control panel start-stop.
      - 3) Accumulated operating hours.



- 4) Accumulated starts.
- 5) Compressor motor status.
- 6) Unit operation code.
- 7) Unit safety fault code.
- 8) Unit cycling fault code.
- 9) Chilled-water pump status.
- 10) Chilled-water flow proof.
- 11) Chilled-water entering temperature.
- 12) Chilled-water leaving temperature.
- 13) Chilled-water leaving temperature set-point adjustment from remote source.
- 14) Condenser water entering temperature.
- 15) Condenser water leaving temperature.
- 16) Evaporator refrigerant pressure.
- 17) Condenser refrigerant pressure.
- 18) Evaporator refrigerant saturation temperature.
- 19) Condenser refrigerant saturation temperature.
- 20) Refrigerant discharge temperature.
- 21) Refrigerant level.
- 22) Refrigerant liquid level setpoint.
- 23) Oil pressure differential.
- 24) Oil sump pressure.
- 25) Oil pump pressure.
- 26) Oil sump temperature.
- 27) High-speed thrust bearing proximity position.
- 28) High-speed thrust bearing proximity reference.
- 29) Motor current percent of full-load amps.
- 30) Motor current phase A.
- 31) Motor current phase B.
- 32) Motor current phase C.
- 33) Motor current set-point adjustment from remote source.
- 34) Motor bearing shaft end vibration.
- 35) Motor bearing opposite shaft end vibration.
- 36) Motor bearing shaft end temperature.
- 37) Motor bearing opposite shaft end temperature.
- 38) Motor average winding temperature.
- 39) Harmonic Filter THD at maximum voltage, percent.
- 40) Harmonic filter total demand distortion at maximum current, percent.
- 41) Harmonic filter total supply kVA.
- 42) Anti-recycle time remaining.
- 43) Liquid line solenoid.
- 44) Pre-rotation vanes position.
- 45) Adaptive capacity control valve surge map installed, true or false.
- 46) Adaptive capacity control new surge point, true or false.
- 47) Adaptive capacity control surge type, pressure differential or current.
- 48) Adaptive capacity control surge count.
- 49) Adaptive capacity control PRV position.
- 50) Adaptive capacity control output frequency.

## 2.10 FINISH

- A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
  - 1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils.
  - 2. Provide at least two coats of alkyd-modified, vinyl enamel finish with a total dry film thickness of at least 3 mils.

## 2.11 SOURCE QUALITY CONTROL

- A. Factory test and inspect refrigerant side of each evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig. Vacuum and pressure test for leaks.
- B. Factory pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure.

## PART 3 - EXECUTION

### 3.1 FACTORY PERFORMANCE TESTS

- A. Provide non-witness factory performance testing for each chiller as specified below. Seller shall indicate any additional chiller delivery time required due to specified factory testing.
  - 1. Four test points verifying reported AHRI 550/590 NPLV.IP performance rating with design evaporator water temperatures and constant condenser water flow.
    - a. 100% load @ 85°F CEWT
    - b. 75% load @ 75°F CEWT
    - c. 50% load @ 65°F CEWT
    - d. 25% load @ 65°F CEWT
  - 2. Four additional test points, again with design evaporator water temperatures and constant condenser water flow.
    - a. 100% load @ 65°F CEWT
    - b. 75% load @ 65°F CEWT
    - c. 75% load @ 55°F CEWT
    - d. 50% load @ 55°F CEWT

### 3.2 FIELD SERVICES

- A. Seller shall protect all materials in such a manner that no harm to the materials and equipment can be done by freezing weather, rain, etc. on the way to the jobsite. Seller shall furnish any necessary protection for such equipment as may be required.

- B. Seller shall provide the services of chiller and chiller VFD manufacturer service representatives and start-up technicians for sufficient time to place each piece of installed equipment furnished by the Seller in satisfactory, operating condition. Time shall also include on-site assistance to the Installing Contractor as specified herein.
- C. The Seller shall provide a minimum of ten (10) full eight-hour normal working days per chiller for onsite field services including but not limited to unloading and installation assistance, start-up and checkout, and Owner's commissioning process assistance. This time is in addition to any travel time required to and from jobsite. This time is exclusive of the personnel training time specified herein. If the Seller feels that the above number of days for assistance, start-up, checkout, and inspection are insufficient, Seller shall include the recommended number of days and cost in his proposal and document the deviation in the bid form in Section 003200 Required Bid Information.
- D. Prior to start-up of chillers and after installation is complete perform inspections.
  - 1. Verify that vibration isolation mounts are properly installed and not directly grounded to floor.
  - 2. Verify that all power and control wiring has been connected to chillers and remote floor mounted VFDs, and that all interconnecting wiring between the VFD and chiller has been properly installed.
  - 3. Charge each chiller with refrigerant and fill with oil.
- E. Provide the services of a certified eddy current testing (ECT) technician to perform on-site eddy current testing on the evaporator and condenser tubes to establish a baseline for comparison with future test results. A minimum of four frequencies shall be used with a low range of approximately 50 Hz and a high range of approximately 1,000 Hz. Submit a written test report to the Owner describing any anomalies or defects with recommended corrective actions.
- F. The manufacturer's service representative shall provide full written reports on final settings, calibrations, and adjustments of all equipment and all start-up and troubleshooting of equipment furnished by the Seller. The representative shall provide written confirmation that chillers and associated components have been installed by the Owner's Installing Contractor in accordance with the manufacturer's recommendations.
- G. Seller shall furnish and install the necessary quantities refrigerant and oil.

### 3.3 STARTUP SERVICES

- A. Provide a factory-authorized service representative to perform startup service for each chiller.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Operate chiller for run-in period.
  - 3. Check bearing lubrication and oil levels.
  - 4. Verify that refrigerant pressure relief devices are properly installed and vented outside.
  - 5. Verify proper motor rotation.

6. Verify static deflection of spring isolation mounts, where applicable, including deflection during chiller startup and shutdown.
7. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
8. Verify and record performance of chiller protection devices.

B. Prepare test and inspection startup reports.

### 3.4 WARRANTY PERIOD TESTING

A. Within one month of warranty period expiration, Seller shall perform the following testing, analysis, and reporting indicated for each chiller.

1. Oil Analysis:

- a. Take oil sample and solicit services of a third-party testing agency, specializing in such analysis, to perform oil analysis.
- b. Submit analysis results and recommendations to Owner.

2. Refrigerant Analysis:

- a. Take refrigerant sample and solicit services of a third-party testing agency, specializing in such analysis, to perform refrigerant analysis.
- b. Submit analysis results and recommendations to Owner.

3. Provide eddy current testing of evaporator and condenser tubes as specified in Paragraph 3.2.E.

4. Inspect ceramic coating on tube sheets and marine water boxes.

5. Site Access and Scheduling:

- a. Contact Owner to schedule testing at least 30 days in advance of testing.
- b. Make mutually agreeable schedule adjustments to accommodate Owner's request for testing.
- c. Review with Owner requirements for visitors in advance of testing.
- d. Comply with Owner requirements for visitors while on-site.

### 3.5 COMMISSIONING SERVICES

A. Seller shall provide on-site assistance during the Owner's commissioning process (construction checklists, functional testing, issue resolution, etc.). Seller shall provide personnel to provide documentation, operate, or adjust system components and otherwise support the Owner's Commissioning Provider (CxP).

B. Provide a minimum of 20 hours total for on-site commissioning assistance.

### 3.6 DEMONSTRATION AND TRAINING

- A. Provide personnel training in accordance with Section 017823 and as specified herein. Engage a factory-authorized service representative to train Owner's operating and maintenance personnel in proper operation, adjustment, and maintenance of all equipment furnished by the Seller under this ITB.
- B. Provide a minimum of 20 normal working hours (four shifts, minimum five hours per shift) of on-site classroom instruction and hands-on field training at the installed equipment. Coordinate all instruction with the Owner. Training sessions specified herein are subject to video recording for future reference by Owner's operations personnel.
- C. Prior to final inspection or acceptance, submit a detailed training syllabus and instructor's resume detailing the training of Owner's designated operating and maintenance personnel in the operation, adjustment, and maintenance of the centrifugal water chillers and all furnished components as specified herein.
- D. Operating and maintenance manuals shall constitute the basis of instruction with additional materials furnished in hard copy and PDF.
- E. The training of Owner's operation and maintenance personnel shall include but not be limited to the following topics:
  - 1. Chiller construction
  - 2. Startup procedures
  - 3. Compressor maintenance and inspection
  - 4. Motor-drive assembly removal, inspection, and repair
  - 5. Microprocessor controller
  - 6. Refrigerant management system
  - 7. Oil lubrication system
  - 8. Alarm notifications and emergency shutdown procedures
  - 9. Operational and safety aspects
  - 10. Use and interpretation of operation and maintenance manuals
  - 11. Preventive maintenance procedures including recommended maintenance schedule
  - 12. Inspection and servicing of refrigerant relief devices
  - 13. Operation of variable frequency drives
  - 14. Operation and maintenance of refrigerant recovery unit (if applicable)

END OF SECTION 236416



# OUHSC Campus

Site Map of Central Utility Plants

Attachment #1  
Site Map

Lincoln Ave.

NE 8th St

Plant 1

Plant 2

Plant 3 Site

N Latite Ave

NE 8th St

Kids Korral, The Tobey Keith Foundation

OU Health Science Center, P.D.

Police Department

United States Postal Service

Google Earth

Image Landsat/Copernicus



500 ft





Attachment #2  
Site Plan

[illegible]