

SECTION 15685 - CENTRIFUGAL CHILLERS - WATER COOLED

PART 1 - GENERAL

1.1 WORK INCLUDED:

- A. Centrifugal water cooled chillers.
- B. Controls and control panel.
- C. Manufacturers shall be responsible to provide any information to the contractor prior to bidding which may impact the installed cost for the contractor including but not limited to:
 - 1. Power wiring sizing quantity and type of conductors.
 - 2. Control power.
 - 3. Auxiliary piping connections.

1.2 BIDDING REQUIREMENTS:

Include life cycle cost form when applicable.

- A. Manufacturer's bid shall include a completed life cycle cost analysis form based on the following criteria at the end of this section.
 - B. Provide KW/Ton versus percent of load graph with bid submittal.
 - C. Proposal shall include fabrication and delivery schedule.
 - D. If disassembling and reassembly is required, that cost shall be a part of this bid.
- 1.3 REFERENCES AND REGULATORY REQUIREMENTS:
- A. ANSI/ASHRAE Standard 15-1994 - Safety Code for Mechanical Refrigeration, with all currently adopted amendments.
 - B. ANSI/ASHRAE 90.1-1989 - Energy Efficiency of New Non-Residential and High Rise Residential Buildings.
 - C. ASME Section VIII - Boiler and Pressure Vessel Code.
 - D. ANSI/UL 465 - Central Cooling Air Conditioners.
 - E. ARI Standard 550/590-98 - a: Provide UL label. Centrifugal or Rotary Water Chilling Packages.
 - F. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.
- 1.4 SUBMITTALS:
- A. Submit product data, shop drawings, and wiring diagrams in accordance with Section 15010.

- B. Quality Control Submittals: Submit certification of compliance with ASME, UL, AND ASHRAE fabrication requirements. Submit proof of manufacturer's qualifications and machine experience specified in Quality Assurance below.
- C. Test Results: Submit results of all factory tests specified below.

1.5 VERIFICATION OF CAPACITY AND EFFICIENCY:

- A. Each chiller shall be factory performance tested under full load conditions in an ARI certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer for inspection. The performance test shall be conducted in accordance with ARI Standard 550/590-98 procedures and tolerances.
- B. All proposals for chiller performance shall include an ARI approved selection method. Verification of date and version of computer program selection or catalog is available through the ARI.
- C. The performance test shall be run with clean tubes in accordance with ARI 550/590-98.
- D. The factory test instrumentation shall be per ARI Standard 500, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology.

Use paragraph E only if a witness test is required.

- E. The Owner or his representative shall be notified 14 days in advance to witness the factory performance test. If the Owner or his representative desires to witness the performance test, all travel, lodging and meal costs will be the manufacturer's responsibility.
- F. A certified test report of all data shall be submitted to the Engineer prior to completion of the project. The factory certified test report shall be signed by an authorized representative of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.

Edit the following carefully, penalty and/or rejection of equipment.

- G. The equipment will be accepted if the test procedures and results are in conformance with ARI Standard 550/590-98. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Owner or his representative to witness the retest. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed.
 1. CAPACITY TEST: For each ton below the allowable capacity as set forth in ARI 550/590-98 of the design capacity, five hundred dollars per ton will be deducted from the contract price.

Allowable capacity = (1 - tolerance) x design capacity; tolerance per ARI 550-90, Section 5.4.

- 2. POWER CONSUMPTION TEST: The power consumption penalty for all load points shall be based upon the tolerances set forth in ARI 550/590-98. The power consumption penalty (P.C.P.) will be calculated based upon the following formula:

$$P.C.P. = \text{Measured KW} - (\text{Measured Tons} \times \text{Allowable KW/Ton}^*) \times \$1000/\text{KW}$$

*Allowable KW/Ton = (1 + tolerance) x design KW/Ton; to tolerance per ARI 550/590-98, Section 5.4.

- 3. TOTAL PERFORMANCE PENALTY: The total performance penalty will be the sum of CAPACITY PENALTY AND POWER CONSUMPTION PENALTY, times the number of typical chillers, regardless if tested.

H. Equipment manufacturer shall not ship the centrifugal chiller(s) until successful completion of the performance test or Owner's acceptance of penalty deduction from the contract.

1.6 SOUND:

- A. Sound Data: The Centrifugal Chiller Sound Pressure Level (SPL), in decibels (dB), with a reference pressure of 20 micropascals, shall not exceed the values listed in "a" below. All rating shall be in accordance with ARI Standard 575-87, "Method of Measuring Machinery Sound Within Equipment Rooms."

EDIT NOTE: Include 1. if system design includes constant condenser water temperature, or 2. if condenser water temperature will be lowered at part load.

- 1. The Owner or his representative shall be notified 14 days in advance to witness the factory performance test. If the Owner or his representative desires to witness the performance test, all travel, lodging and meal costs will be the manufacturer's responsibility.
- 2. Condenser water temperature may be reduced at part load conditions as allowed by ARI 550/590.

EDIT NOTE: Engineer to complete. Either leave values in Table a. or have manufacturer's representative provide if lower sound is required.

a. Allowable Sound Levels:

% Load	dB, A Weighted
100	87
50	90
25	90

- B. Sound Pressure Test: The chiller (one of each size) shall have a sound test conducted at the factory prior to shipment to confirm the Sound Pressure Levels submitted in Section 3.01.A. above. All data must be measured and presented in strict accordance with ARI Standard 575-87.

If a witness test is required, use paragraph 1 and 4.

1. The Project Engineer or his representative must be present to witness the test.
2. In the event that a chiller does not meet the submitted dBA sound pressure level, the manufacturer must, at his expense, provide sufficient attenuation to the machine to meet the submitted value. This attenuation shall be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller.
3. If the unit cannot be modified to meet the submitted SPL levels, sufficient funds will be deducted from the purchase order to cover materials and labor for jobsite attenuation to bring the sound levels to an acceptable level.
4. The Project Engineer or his representative must witness the test after attenuation to confirm that the submitted values are met. The manufacturer will assume all expenses incurred by the project engineer or his representative to witness the retest.

1.7 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of centrifugal chillers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. 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.

1.8 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver chillers as a complete factory-assembled unit with protective crating and covering.
- B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting unit.
- C. Ship chillers charged, or with a nitrogen holding charge in one or two pieces, depending upon size.
- D. Coordinate the delivery of the chiller(s) in sufficient time to allow movement into the building.
- E. Store, on site, in a dry/clean environment. Protect chiller(s) from physical damage. Leave factory shipping covers in place until installation is complete.
- F. Additional Refrigerant: Coordinate delivery of refrigerant to the site with Contractor in charge. Store in a dry/clean environment until storage room of building is complete.

1.9 SEQUENCING AND SCHEDULING:

- A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.
- B. Concrete, reinforcement, and formwork requirements are specified in Division 3.

Coordinate warranty time duration with the Owner. Get budget pricing from manufacturer's representative.

1.10 WARRANTY:

- A. Provide ____ year warranty including all parts, labor, materials, transportation and shipping charges with no cost to the Owner. All compressors motors, driveline and shaft seals shall have a minimum warranty period of 2 / 5 years for all parts and labor (at no cost to the Owner).
- B. Warranty shall not begin until the Owner has accepted the temperature control system.

Include maintenance service if Owner requests. This is normally not specified.

1.11 MAINTENANCE SERVICE:

- A. Furnish service and maintenance of chillers immediately after substantial completion for a period of [] years including all parts, labor and miscellaneous costs. Maintenance shall include all service indicated in the operation and maintenance manual over the time period indicated above. In addition to the manufacturer=s recommendations, provide the following annual service:
 - 1. Oil Analysis - change as required.
 - 2. Clean tubes.
 - 3. Full driveline inspection - report only.
(Service falls under warranty period above)
 - 4. Megger Test, motor - report only.
 - 5. (Service falls under warranty period above)

PART 2 - PRODUCTS

2.1 SUMMARY:

- A. The contractor shall furnish and install centrifugal water chillers as shown and scheduled in the plans. The units shall be installed in accordance with this specification and produce the specified tonnage per the scheduled data in accordance with ARI 550/590-98. The unit shall bear the ARI certification label as applicable.

2.2 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Centrifugal Chillers:
 - a. A/C Group; Corp.
 - b. Trane Co., The
 - c. York Int'l.
- B. Chiller shall be a complete factory package including a centrifugal compressor, open or hermetically sealed motor, compressor motor starter, cooler, condenser, purge unit. Unit shall be factory assembled, piped, wired, leak tested and painted with a minimum of two coats of primer paint and two coats of finish paint.

2.3 REFRIGERANT;

A. The following refrigerant are acceptable:

1. R-22
2. R-123
3. R-134a

2.4 COMPRESSOR AND MOTOR:

A. The compressor shall be centrifugal.

B. The compressor shall have an impeller wheel of cast high strength aluminum alloy. The shaft bearings shall have forced feed lubrication. The variable inlet vane guide at the compressor inlet shall provide capacity modulation of 100% of 10% of design load with 4°F reduction in entering condenser water temperature per 10% reduction in capacity per ARI Standard 550/590-98. This shall be accomplished at constant full load water flow rates by varying the volume of gas handled by the compressor. The guide vanes shall be operated by the refrigeration load on the evaporator. Impeller (s) shall be dynamically balanced and tested at a minimum of 4500 RPM.

C. Compressor assembly shall be run-tested at the factory. Vibration shall not exceed 1.0 mil peak to peak.

EDIT NOTE: Design of chiller room may be affected by open vs. hermetic motor. Consider motor heat and room cooling. If significant, spell out alternate designs on drawings.

D. Hermetic Motors (Trane,)

1. Motors shall be refrigerant cooled, single speed, hermetically sealed, squirrel cage induction type.
2. Motor shall be assembled for each service and removal without breaking the main refrigerant piping connections.
3. Motor shall be suitable for 60 hertz, three phase power.

E. Open Drive Motors (York,):

1. Motors shall be open drip proof, single speed, squirrel cage, induction type.
2. Motors shall be rigidly coupled to the compressor. Provide factory alignment of motors and compressor shafts.
3. Motor shall be assembled to allow access for repair or removal without removing the refrigerant charge from chiller.
4. Provide a motor-compressor shaft seal leakage containment system.
5. Motor shall be suitable for 60 hertz, three phase power.

F. The lubrication system shall be of the force feed type with an oil pump supplying oil under pressure to all bearings, gears, and rotating surfaces. The oil pump shall be external to the compressor. The lubrication system shall provide a positive supply of oil to all bearings even during a power failure shutdown to the compressor. A replaceable external oil filter with

provisions for servicing without removing the unit refrigerant charge shall be provided. A refrigerant or water cooled oil cooler shall be provided. Heater shall be furnished in the oil reservoir. Complete lubrication system shall be factory installed and piped. Provisions shall be made within the control panel to furnish power for the oil pump, heater and oil cooler without the necessity of an additional external electrical connection(s).

- G. Provide a rupture disk and a reseatable relief valve for low-pressure (R-123) chillers. Provide a relief valve for all high pressure chillers (R-134a, R-22).

Edit for appropriate pressures and pipe connections.

2.5 EVAPORATOR AND CONDENSER:

- A. The evaporator and condenser shall be built in accordance with ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration, ASME Code construction and stamped. Water boxes shall be designed for 300/150 PSIG maximum working pressure. The water piping connections shall be flanged.
- B. Water velocity through evaporator and condensers tubes shall not exceed 8 feet per second.

Choose one of the following C and D Paragraphs

- C. Evaporator and Condenser tube. Nominal tube wall thickness shall be minimum .025 inches.
- D. Supply and return head water boxes shall be designed for a working pressure of 150/300 psig and shall be subjected to a factory hydrostatic pressure test of 225/450 psig. Provide drain and vent connections in water boxes.

Use marine water boxes where required; they normally are not used on most projects. They are used for ease of tube cleaning typically in the condenser only.

- E. Marine water boxes with side connections for the evaporator and condenser shall be provided such that the water piping of both the entering and leaving sides need not be disconnected for mechanical cleaning. The water piping connections shall be in a direction perpendicular to the shells to allow full unblocked access to the tubes
- F. Factory insulation shall be 3/4" or 1-1/2" elastomeric foam insulation (maximum k=.28 BTU/ft² - HR) and cover all low temperature surfaces to include the evaporator and water boxes, suction elbow, economizer and motor cooling lines.
- G. Provide factory installed refrigerant sight glass.

EDIT NOTE: Verify need for epoxy coating - \$10-\$15K adder.

- H. Provide factory applied epoxy coating for condenser/and evaporator tube sheet(s) and all four/both water box heads.
- I. Provide lifting eye hooks on all four water boxes for maintenance.
- J. Cooler shall contain integral mist eliminators to prevent carryover of liquid refrigerant into compressor suction.

- K. Provide factory supplied refrigerant and oil shipped to job site ready for installation by the factory authorized representative.

2.6 PURGE SYSTEM:

- A. The manufacturer of low pressure machines, must provide a separate compressor type purge system providing positive means of collection, return of refrigerant and removal of non-condensables. No external water cooling source is to be required.
- B. The purge unit shall include necessary operating controls, piping, and refrigerant service valves to isolate the purge unit from the chilling unit. The purge unit shall be completely factory mounted, piped and wired.
- C. Any excess purge requirement will enable a fault indication light at the purge and a contact closure shall be provided for remote annunciation. Provide an elapsed time meter.

Choose one of the two following starter sections. Carefully coordinate electrical wiring requirements with electrical engineer.

2.7 STARTER (HIGH VOLTAGE OVER 600 VOLTS):

- A. HAND-OFF-AUTO motor starter shall Across The Line / Auto-Transformer / Primary Reactor type.
- B. Isolating switch and contactor assemblies, including current limiting fuses shall be of the component-to-component design without any interconnecting cables or flexible shunts. They shall be easily removed from the front of the enclosures. Line and load cable terminations shall be completely accessible from the front.
- C. The isolating switch shall be an externally operated manual three pole draw-out, such that in the open position it completely grounds and isolates the starter from the line connectors with a mechanically driven isolating shutter leaving no exposed high voltage. Integral mechanical interlocks shall prevent entry into the high voltage areas while the starter is energized and shall block accidental opening or closing of the isolating switch when the door is open or contactor is closed. The isolating switch handle shall have provision for three padlocks.
- D. Current limiting power fuses shall be of the self-protecting type with visible fuse condition indicators, and with special time/current characteristics for motor service allowing proper coordination with the contractor and overload protection for maximum motor protection. The power fuses shall be vertically mounted permitting easy inspection and replacement without starter disassembly.
- E. The vacuum contactor shall be slide out, with single break high pressure type main contacts with weld-resistant alloy contact faces. For vacuum contactors the contact wear shall be easily checked with the use of a feeler gauge and the bottle gap shall be adjustable. A built-in test circuit shall be included to permit checking of the starter control and pilot circuit with the high voltage de-energized and isolated, with the contactor in its normal position. In the test mode, the control circuit shall be capable of being energized through a polarized plug connector from an external 115 volt supply.

- F. The low voltage control shall be isolated by a barrier from the high voltage area, and provided with a separate low voltage access door. The low voltage panel shall be accessible by sliding the unit out.
- G. Enclosures for the high voltage starters shall meet ANSI/NEMA ICS-6 enclosure standards and shall be NEMA 1, unless otherwise noted, completely front accessible and allowing free-standing against a wall or back-to-back mounting. Where multiple starter/structure installations are required, horizontal power bus should be used to connect between structures located on the top. Vertical bus to connect tiered starter units shall be insulated and integral to the enclosure.
- H. The starter shall be able to operate in temperatures up to 120°F.
- I. All field supplied wires, bus bars and fittings shall be copper only.
- J. The following starter features shall be provided:
 1. Ammeter: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated.
 2. Voltmeters: Three voltmeters shall be provided, each reading a phase to phase voltage.
 3. Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5 percent at full load conditions.

EDIT NOTE: May be no longer required. Public service corrects at transformer.

Coordinate carefully with chiller manufacturer and electrical engineer wiring requirements if factory or field mounted starter. Normally factory mounted started starters should be specified for machine up to 1000 tons, over 1000 tons unit mounted starters are not practical due to starter size. Consult with manufacturer.

2.8 STARTERS (LOW VOLTAGE LESS THAN 600 VOLTS:

EDIT NOTE: Stardelta

- A. HAND-OFF-AUTO motor starter shall be a Star-Delta Closed Transition (Trane, McQuay,) OR Reduced Voltage Solid State (York, , Trane, McQuay) and shall have a NEMA 1A gasketed enclosure. Enclosure shall be constructed of 12 gauge steel minimum with the exception of doors, which shall be 14 gauge steel minimum. Unit mounted enclosures shall have ventilating louvers. Gasketing shall be 2" width minimum. Each door or enclosure more than 48" high shall have 3 point vault type latches with padlockable handles. Motor starter(s) shall be factory mounted and wired on the chiller/field mounted and wired as shown on plans.
- B. Motor starters shall include incoming line provisions for the number and size cables shown on the drawings. Incoming line lugs shall be copper mechanical type. Connection directly to the contactors is not permissible. All components shall be mounted to a removable steel panel of 14 gauge minimum.

- C. Contactors shall be sized properly to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall be low resistance having palladium silver contacts.

Select larger KVA capacity if desired; 2 KVA should be minimum.

- D. Each motor starter shall include a 2 KVA control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.
- E. Power wiring within the starter shall be type MTW copper stranded 90°C. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be type MTW copper stranded 90°C 14 gauge minimum.
- F. The starter shall be able to operate in temperatures up to 120°F.
- G. All field supplied wires, bus bars, and fittings shall be copper only.

EDIT NOTE: Talk to Electrical, as code only requires a non-fused disconnect within sight of chiller, and a circuit breaker or fuses are provided upstream at panel.

- H. The following starter features shall be provided:
1. Circuit Breaker: Starter shall contain a circuit breaker capable of breaking currents up to its interruption capacity of 65,000 amperes with ground fault protection. Operating handle and trip indicator shall be located in the door. This handle shall be capable of being padlocked.
- OR
2. A non-fused disconnect switch shall be provided.
 3. Ammeters: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated.
 4. Voltmeters: Three voltmeters shall be provided, each reading a phase to phase voltage.
 5. UL approved.

EDIT NOTE: Verify requirements with electrical. Usually corrected at transformer by Public Service.

6. Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5 percent at full load conditions.
- I. The starter shall be factory tested. Design current and overload settings shall be factory adjusted.

2.9 ADJUSTABLE FREQUENCY DRIVES, FACTORY MOUNTED ON CHILLER:

A. Adjustable frequency drives, factory mounted on chiller:

1. The centrifugal water chiller shall be furnished with a liquid cooled adjustable frequency drive as shown on the drawings. The AFD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.
2. The AFD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The AFD control logic shall optimize chiller efficiency by coordinating compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, AFD surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.
3. The drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be a minimum 0.96 lagging at all speeds and loads.
4. The adjustable frequency drives shall be solid state, microprocessor based pulse width modulated (PWM) design. The AFD shall be voltage and current regulated. Output power devices shall be IGBT transistors.
5. Power semi-conductor and capacitor cooling shall be from a liquid cooled heatsink.
6. The AFDs shall each be furnished in a NEMA 1 metal enclosure having as minimum a short circuit withstand rating of 65,000 amps per UL 508. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.
 - a. Enclosure shall include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amp.
 - b. The entire chiller package shall be UL/CUL listed.
7. The AFD shall be tested to ANSI/UL Standard 508 and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.
8. Compliance to IEE 519-1992:
 - a. The AFD design shall include as standard integrated active rectification control to limit total current distortion (TDD) at the AFD to less than 5-percent.
9. Input shall be nominal 480 volts, three phase, 60 Hertz AC power, +/- 10 percent of nominal.
10. Line frequency 38-60 hertz.
11. The drive units shall include the following features:
 - a. All control circuit voltages are physically and electrically isolated from power circuit voltage.
 - b. One hundred fifty percent instantaneous torque available for improved surge control.
 - c. Minimum and maximum speed adjustments.
 - d. Soft start, adjustable linear acceleration, coast to stop.
 - e. Adjustable current limiting and UL approved electronic motor overload protection.

- f. Insensitivity to incoming power phase sequence.
 - g. AFD and motor protection from the following faults:
 - 1) Output line-to-line and line-to-ground short circuit phase loss at AFD input.
 - 2) Over-volt, under-volt, over temp., ph.rever
 - h. Carrier frequency shall be fixed at 2 Khz for maximum efficiency.
 - i. Automatic operation at minimum speed if the input reference is lost.
12. The following features shall be provided:
- a. A door interlocked circuit breaker capable of being padlocked.
 - b. UL listed ground fault protection.
 - c. Overvoltage and undervoltage protection.
 - d. 3-phase sensing motor overcurrent protection.
 - e. Single-phase protection.
 - f. Insensitive to phase rotation.
 - g. Over-temperature protection.
13. In addition to the above features the following AFD status indicators shall be available to facilitate start-up and maintenance:
- a. Output speed in hertz and rpm
 - b. Input line voltage
 - c. Input line kW and kilowatt-hours (KWH)
 - d. Output/load amps/voltage
 - e. Average current in percent RLA
 - f. Load power factor
 - g. Fault
 - h. AFD transistor temperature
 - i. Self diagnostic service parameters
14. Service Conditions – At full output power, no external venting or heat exchangers shall be required:
- a. Operating ambient temperature 32-104 F (0-40 C).
 - b. Room ambient 0-95% relative humidity.
 - c. Elevation to 300 feet above 3300 feet, the rated output current shall be decreased by one percent.
15. Provide input line reactor that limits electrical power supply distribution for the variable speed drive. Input line reactor shall be unit mounted within the same NEMA-1 enclosure and shall be UL listed. Total harmonic distortion (THD) shall not exceed 3%.
16. Provide solid state manual bypass for the transfer of start and run functions from the AFD to input line power. Solid state manual bypass to provide a soft start in the bypass mode. Provide in a separate factory-mounted expansion enclosure and include inverter-off-bypass switch, separate circuit breaker with shunt trip assembly, chiller starter module, and CTs and output contactors.
17. Provide a positive electrical disconnect between the AFD and motor.

2.10 CONTROLS:

EDIT NOTE: CHOOSE

- A. The chiller(s) shall be controlled by a stand-alone Direct Digital Control (DDC) System. A dedicated chiller control panel is to be supplied with each chiller by the chiller manufacturer. The panel shall be microprocessor-based, with factory wired and test for all required control components for reliable equipment operation.

OR

The chiller(s) shall be capable of communicating with Johnson Metasys System by a stand-alone Direct Digital Control (DDC) System through a BACnet interface. The following communication data shall be provided as a minimum through the BACnet interface from the chiller control panel(s):

<u>OBJECT TYPE</u>	<u>GENERIC DATA NAME</u>
AIP	<u>Leaving Chilled Water Temperature</u>
AIP	<u>Entering Chilled Water Temperature</u>
AIP	<u>Leaving Condenser Water Temperature</u>
AIP	<u>Entering Condenser Water Temperature</u>
AIP	<u>Percent RLA</u>
AIP	<u>Evaporator Refrigerant Pressure</u>
AIP	<u>Condenser Refrigerant Pressure</u>
AIP	<u>Compressor Discharge Refrigerant Temperature</u>
AIP	<u>Evaporator Refrigerant Temperature</u>
AIP	<u>Condenser Refrigerant Temperature</u>
AIP	<u>Oil Temperature</u>
AIP	<u>Oil Pressure Differential</u>
BIP	<u>Oil Pressure Differential</u>
BIP	<u>Condenser Water Flow</u>
BIP	<u>Chiller Water Flow</u>
BIP	<u>Manual Reset Alarm</u>
BIP	<u>Auto Reset Alarm</u>
BIP	<u>Controller Communications</u>
BOP	<u>Chiller Enable/Disable</u>
BOP	<u>Spare BOP</u>
AOP	<u>Chilled Water Setpoint</u>
AOP	<u>Current Limit Setpoint</u>

- B. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches. The panel shall be a complete system for stand-alone chiller control and includes controls to safely and efficiently operate the chiller. Provision shall be made in the control center for inter-locking of compressor motor starter(s), chilled water flow switch(es), chilled water pump(s), condenser water pump(s) and cooling tower fan(s) per the manufacturer's recommendations.
- C. Safeties: The chiller control panel shall monitor such safeties as motor starting and running, time between compressor/motor starts, low chilled water temperature, high condenser refrigerant pressure, low evaporator refrigerant temperature, evaporator and condenser water flows, low oil pressure, high oil temperature, and proper operation of unit controls and sensors.
1. To monitor bearing temperatures, all of the compressor motor bearings, (including high speed, low speed, and thrust bearings) shall have a factory installed temperature sensor installed in the oil return lines or the oil sump of each motor bearing or the oil sump. If any oil temperature reaches or exceeds a set value, the chiller control panel shall shut down the chiller operator and display the diagnostic.
 2. The chiller control panel shall incorporate advanced motor protection to protect the motor throughout the starting and running cycles from the adverse affects of:
 - a. Overcurrent
 - b. Phase imbalance
 - c. Phase reversal with indicating light
 - d. Phase loss/failure with indicating light
 - e. Low voltage
 - f. Distribution fault protection with auto restart consisting of three-phase, current sensing devices that monitor the status of the current.
 - g. Locked rotor or incomplete start sequence.
 3. Alternately the advanced motor protection system can be furnished in the starter.
 4. Provide electrical interlock to prevent chiller operation when condenser water pump and chilled water pump is not operating.
 5. Manual reset safety controls with separate indicating lights for:
 - a. High oil temperature
 - b. High and low refrigerant pressure
 - c. Low oil pressure
 - d. Automatic reset low leaving chilled water temperature cutout
 - e. Chilled water flow and power failure
- D. The chiller control panel is to be provided with a starts counter and running time meter.
- E. The front of the chiller control panel shall be capable of displaying the following:
1. Entering and leaving evaporator water temperature
 2. Entering and leaving condenser water temperature
 3. Chilled water setpoint
 4. Electrical current limit set point
 5. Chiller operating mode

6. Evaporator and condenser temperatures.
 7. Low and high oil pressure
 8. Diagnostics: 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.
 9. Motor current controller with load limit selector switch for full modulation from 40% to 100% full load amps.
 10. Compressor HAND-OFF-AUTO switch and operating signal light.
 11. Provide switches and push-buttons designed to permit indicated operations including the following:
 - a. Manual and automatic operation of oil pump.
 - b. Manual and automatic operation of oil separator heater.
 - c. Provide indication at the micropanel of operations and cutouts including the following:
 - d. Oil pump operation.
 - e. Low chilled water temperature cutout.
 - f. Low water flow cutout.
 - g. Oil separator heater operation.
 - h. Low evaporator refrigerant pressure or temperature cutout.
 - i. High condenser pressure cutout.
 - j. High motor winding temperature cutout (hermetic).
 - k. High current cutout (open).
 - l. Low oil pressure cutout.
 - m. Motor overload cutout.
- F. The chiller control panel shall provide evaporator freeze protection and low limit control. This control shall be used to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and temperature. A diagnostic code, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.
- G. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.
- H. The chiller control panel shall provide condenser limit control to include a pressure transducer and interconnecting piping and wiring. This control shall be used to avoid high condenser refrigerant pressure tripouts during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and actual value of the condenser refrigerant pressure. A diagnostic code, reflecting the operating status, shall be automatically displayed at the front panel whenever this control mode is in effect.
- I. The unit control panel shall provide leaving chilled water temperature reset based upon a 4-20 ma or 0-10 VDC signal from a building automation system.

EDIT NOTE: Specify pump-out system only if desired by Owner. Verify current requirements and enforcement of Colorado Air Quality Control Division Regulation 15.

2.11 PUMP-OUT SYSTEM:

- A. All units shall have either an isolatable condenser or a pump-out system complete with transfer pump, condensing unit, relief valve, and tank constructed in accordance with ASME Code for unfired pressure vessels bearing the National Board stamp. The condenser shall be sized to hold the entire refrigerant charge. The pump-out system shall hold the entire charge of the largest single chiller.
- B. Pump-out systems shall be supplied and warranted by the chiller manufacturer.

2.12 REFRIGERANT MONITOR:

EDIT NOTE: COORDINATE WITH TEMP CONTROLS SECTIONS. SPECIFY MONITOR HERE, SPECIFY INTERLOCKS AND FAN CONTROL IN CONTROLS SECTION.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install chillers in accordance with manufacturers installation instructions.
- B. Install chillers plumb and level, firmly anchored, and maintain manufacturer's recommended clearances for servicing and maintenance.
- C. See Section 15241 for vibration isolation.

3.2 PIPING CONNECTIONS:

- A. Piping installation requirements are specified in other sections of Division 15. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
 1. Install piping adjacent to machine to allow servicing and maintenance.
 2. Chilled Water Piping: Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, pressure gauge, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, flow meters, thermometer, pressure gauge, and union or flange.
 3. Condenser Water Piping: Provide flanged connections to condenser, arranged piping to allow removal of condenser heads. Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gauge. Connect outlet to condenser with shutoff valve, flow meter, thermometer, drain line and shutoff valve, strainer, and plugged tee.

EDIT NOTE: For heat recovery chillers.

- 4. Auxiliary Condenser: Provide bypass valve to bypass water flow around auxiliary condenser.

5. Vent Piping: Provide drain piping as indicated from pressure relief device to suitable drain.

3.3 FIELD QUALITY CONTROL:

- A. 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.

3.4 DEMONSTRATION:

- A. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.
- B. Start-up Service:
 1. 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.
 2. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.
 3. Do not place chillers in sustained operation prior to initial balancing of mechanical systems for interface with chillers.
- C. Training:
 1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the data contained in the Operating and Maintenance Manuals specified in PART 1 of this Section and in Division One.
 2. Schedule training with Owner through the Architect/ Engineer with at least 7 days prior notice.

END OF SECTION 15685

The following is a sample form, which can be used and includes ratchet clause. Use on project when necessary. Requires a pre-purchase analysis by CRA.

CH-_____ TON CHILLER
LIFE CYCLE COST FORM

Manufacturer _____
Model No. _____
Installed Cost _____
Delivery Date _____

Peak KW: _____ KW
Annual KW-H _____ KW-H (Calculation based on load data provided and manufacturers chiller performance selection)

YR	KW-H					DEMAND					Total K2-H + Demand	PW @ 9%
	KW-HR	X	\$/KW-HR	=	\$	PEAK KW	X	\$/KW	=	\$		
01	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
02	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
03	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
04	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
05	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
06	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
07	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
08	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
09	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
10	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
11	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
12	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
13	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
14	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
15	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
16	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
17	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
18	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
19	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____
20	_____	X	_____	=	_____	_____	X	_____	=	_____	\$ _____	_____

TOTAL PW OF OPERATING COST = \$ _____

CHILLER COST = \$ _____

TOTAL LIFE CYCLE COST = TOTAL PW OPERATING COST PLUS
INSTALLED CHILLER COST \$ _____

The following is a sample of annual operating performance. Edit to make suitable for each project when required.
--

CH-1 (850 TON CHILLER)

Building Tons	Annual Operating Hours	Min. Entering Condenser Water Temp.
850	21.2	80
462	54.9	80
450	152.9	80
440	311.0	75
430	457.8	75
418	563.8	72
406	632.1	70
395	675.3	70
385	678.7	68
374	647.9	65
363	623.1	60
350	617.4	60

CH-2 (550 TON CHILLER) Alternate Bid

Building Tons	Annual Operating Hours	Min. Entering Condenser Water Temp.
550	21.2	80
462	54.9	80
450	152.9	80
440	311.0	75
430	457.8	75
418	563.8	72
406	632.1	70
395	675.3	70
385	678.7	68
374	647.9	65
363	623.1	60
350	617.4	60