**PART 1 – GENERAL**

**1.01 SUMMARY**

A. Section Includes: Water cooled chiller with oil lubricated single or dual compressors.

B Related Requirements:

1. Division 01: General Requirements.

2. Section 22 10 00: Plumbing.

3. Section 23 05 00: Common Work Results for HVAC.

4. Section 23 05 13: Basic HVAC Materials and Methods.

5. Section 23 07 00: HVAC Insulation.

6. Section 23 09 00: HVAC Instrumentation and Controls.

7. Section 23 20 13: Above Ground HVAC Piping.

8. Section 23 20 16: Underground HVAC Piping.

9. Section 23 25 00: HVAC Water Treatment.

10. Section 23 65 00: Cooling Towers.

11. Section 31 23 23: Excavation and Fill for Utilities.

**1.02 QUALITY ASSURANCE**

A. Installers and Manufacturer's Qualifications: Comply with provisions stated in Section 23 0500: Common Work Results for HVAC.

1. Regulatory Requirements:
2. ANSI/ASHRAE STANDARD 15 – Safety Standard for Refrigeration Systems.
3. ANSI/ASHRAE/IESNA 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. ASME – Boiler and Pressure Vessel Code, Section VIII.
5. UL 1995 – Heating and Cooling Equipment.
6. ANSI/AHRI 270 – Standard for [Sound Rating of Outdoor Unitary Equipment](http://webstore.ansi.org/RecordDetail.aspx?sku=ARI+270-95).
7. ANSI/AHRI 370 – Standard for [Sound Performance Rating of Large Air-Cooled Outdoor Refrigerating and Air-Conditioning Equipment](http://webstore.ansi.org/RecordDetail.aspx?sku=ARI+370-2001).
8. ANSI/AHRI STANDARD 550/590 – Standard for Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle.
9. ANSI/AHRI 575 – Standard for Method of Measuring Machinery Sound Within an Equipment Space.
10. ANSI/ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.
11. ASHRAE STANDARD 34 – Designation and Safety Classification of Refrigerants.
12. Chiller shall be designed and constructed to meet UL or ETL requirements and have labels appropriately affixed.

**1.03 SUBMITTALS**

A. Provide submittals in accordance with Division 01 and Section 23 05 00: Common Work Results for HVAC.

B. Manufacturer’s Data:

1. Complete list of items proposed to be furnished and installed under this Section. Material lists, which do not require performance data, shall include manufacturer’s names, types, and model numbers for usages indicated.

2. Manufacturer's specifications and data required to demonstrate compliance with specified requirements. Literature shall include descriptions of equipment, types, models and sizes proposed, capacity tables or curves marked to indicate performance characteristics, electrical requirements, options selected, space requirements (including allowances for servicing if indicated) and data necessary to ensure compliance with requirements of these Specifications and performance indicated on Drawings. Data shall also include name and address of nearest service and maintenance organization that regularly stocks repair parts. Listings of items that function as parts of an integrated system shall be furnished at one time.

3. Shop Drawings indicating methods of installation of equipment and materials, sizes, and schedules of piping, and details of supports. Items to be indicated shall include but are not limited to, the following:

a. Layout of proposed piping and equipment drawn to scale, to establish that equipment will fit into allotted spaces with clearance for installation and maintenance. Indicate proposed details for attachment, anchoring to, and hanging from structural framing of building. Indicate vibration isolation units, foundations and supports, and openings for passage of pipes

b. Drawings indicating locations and sizes of sleeves and prepared openings for pipes.

c. Typical details of supports for equipment and piping.

4. Submit drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves.

5. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

6. Submit manufacturer’s installation instructions.

7. Submit performance data indicating energy input versus cooling load output from 10 (or minimum turn down) to 100 percent of full load.

**1.04 PRODUCT HANDLING**

A. Protection, Replacements, Delivery and Storage: Comply with provisions stated in Section 23 0500: Common Work Results for HVAC.

B. Deliver chillers to the job site completely assembled and charged with refrigerant and oil by the manufacturer.

C. Comply with manufacturers instructions for rigging and handling.

**1.05 COORDINATION**

A. Coordinate related and adjacent activities in accordance with provisions of Section 01 3113: Project Coordination.

**1.06 WARRANTY**

A. Compressors shall carry five year parts only warranty.

B. One year parts and labor warranty on entire unit including controls and refrigerant.

**PART 2 – PRODUCTS**

**2.01 EQUIPMENT**

A. Cooling and heating capacities, electrical characteristics, outdoor sound levels and operating conditions shall be as indicated on the Drawings.

B. Capacities of equipment and material shall be not less than those indicated on Drawings. Capacities of refrigerating equipment as indicated on Drawings are net rated output as required, based on load and ambient air temperature condition at the Project site. Ambient air temperature indicated for rating purposes is standard in manufacturer's tables.

C. Unit Description:

1. Provide and install as shown on the plans a factory-assembled, factory charged, water-cooled packaged chiller. Each unit shall be complete with a [single or dual] hermetic centrifugal compressor as scheduled with lubrication and control system, factory mounted starter, evaporator, condenser, refrigerant control device and any other components necessary for a complete and operable chiller package.

2. Chillers shall be factory run-tested on an AHRI certified test stand with water at job conditions. Operating controls shall be adjusted and checked. The refrigerant charge shall be adjusted for optimum operation and recorded on the unit nameplate. Any deviation in performance or operation shall be remedied prior to shipment and the init retested if necessary to confirm repairs or adjustments. See schedule for single or dual compressor designation.

D. Chiller shall be constructed and rated in accordance with AHRI 550/590. Chiller shall conform to ASHRAE 15. Chiller shall be designed and constructed to meet UL or ETL requirements and have labels properly affixed.

1. Manufacturer: McQuay, Carrier, Trane, York, or equal.

2. Capacity: As indicated on drawings.

3. Quality Assurance: Design, construction, testing and installation shall comply with the following standards as applicable:

a. ASHRAE/IESNA 90.1.

b. Sound Level: AHRI Standard 575.

4. Energy Efficiency: As indicated on drawings.

**2.02 DESIGN REQUIREMENTS**

A. General: Provide a complete water-cooled hermetic centrifugal compressor water-chilling package as specified herein. In general, unit shall consist of a compressor, condenser, evaporator, lubrication system, starter and control system.

B. Performance: Refer to schedule on the drawings. The chiller shall be capable of stable operation to ten percent of full load with standard AHRI entering condensing water relief without the use of hot gas bypass.

C. Acoustics: Sound pressure levels for the complete unit shall not exceed the following specified levels. Provide the necessary acoustic treatment to chiller as required. Sound data shall be measured according to AHRI Standard 575. Data shall be in dB. Data shall be the highest levels recorded at all load points. Test shall be in accordance with AHRI Standard 575.

**2.03 CHILLER COMPONENTS**

A. Compressor:

1. Unit shall have a hermetic centrifugal compressor. Casing design shall ensure major wearing parts, main bearings, and thrust bearings are accessible for maintenance and replacement. The lubrication system shall protect machine during coast down period resulting from a loss of electrical power.
2. The impeller shall be statically and dynamically balanced. The compressor shall be vibration tested and not exceed a level of 0.14 IPS.
3. Movable inlet guide vanes actuated by an internal oil pressure driven piston shall accomplish unloading. Compressors using an unloading system that requires penetrations through the compressor housing or linkages, or both that must be lubricated and adjusted are acceptable provided the manufacturer provides a five-year inspection agreement consisting of semi-annual inspection, lubrication, and annual change out of any compressor seals. A statement of inclusion must accompany any quotations.
4. For open motor units, an oil reservoir shall collect any oil and refrigerant that leaks past the seal. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing. Manufacturer shall warrant the shaft seal, reservoir, and float valve system against leakage of oil and refrigerant to the outside of the refrigerating unit for a period of five years from the initial start-up including parts and labor to replace a defective seal and any refrigerant required to trim the charge original specifications.
5. Lubrication System: The compressor shall have an independent lubrication system to provide lubrication to all parts requiring oil. Provide a heater in the oil sump to maintain oil at sufficient temperature to minimize affinity of refrigerant, and provide a thermostatically controlled water-cooled oil cooler. Coolers located inside the evaporator or condenser are not acceptable due to inaccessibility. A positive displacement oil pump shall be powered through the unit control transformer.
6. Refrigerant Evaporator and Condenser:
7. Evaporator and condenser shall be of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.1 times the working pressure, but not less than 100 psig. Provide intermediate tube supports at a maximum of 24-inch spacing.
8. Tubes shall be enhanced for maximum heat transfer, rolled into steel tube sheets, and sealed. The tubes shall be individually replaceable.
9. Provide isolation valves and sufficient volume to hold the full refrigerant charge in the condenser or provide a separate pump out system with storage tank.
10. The water sides shall be designed for a minimum of 150 psi or as specified elsewhere. Vents and drains shall be provided.
11. Evaporator minimum refrigerant temperature shall be 33 degrees F.
12. An electronic or thermal refrigerant expansion valve shall control refrigerant flow to the evaporator. Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have a moisture indicating sight glass.
13. The evaporator and condenser shall be separate shells. A single shell containing both vessel functions is not acceptable because of the possibility of internal leaks.
14. Reseating type spring loaded pressure relief valves according to ASHRAE 15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the vessel. Rupture disks are not acceptable.
15. The evaporator, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 3/4 inch closed cell insulation. Joints and seams shall be carefully sealed to form a vapor barrier.
16. Provide factory-mounted thermal dispersion flow switches on each vessel to prevent unit operation with no flow.

D. Prime Mover: Squirrel cage induction motor of the hermetic type of sufficient size to efficiently fulfill compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase. Motor shall be compatible with the starting method specified hereinafter. If the Contractor chooses to provide an open drive motor or compressor, verify in the submittal that the scheduled chiller room ventilation system will accommodate the additional heat and maintain the equipment room at design indoor temperature based on 95 degrees°F outdoor ambient ventilation air available.

1. If additional cooling is required, manufacturer shall be responsible for the installation, wiring and controls of a cooling system. Chiller selection shall compensate for tonnage and efficiency loss to make certain the owner is not penalized.

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| **EDIT NOTE: SELECT FROM THE PARAGRAPHS 2.03.E PRESENTED BELOW FOR CONVENTIONAL MOTOR STARTER OR VFD.** |

E. Motor Starter:

1. The main motor starter is to be factory mounted and fully wired to the chiller components and factory tested during the run test of the unit.
2. The starter must comply with the codes and standards in Article 1.02.
3. Low Voltage (200 through 600 volts) motor controllers are to be continuous duty AC magnetic type constructed according to NEMA standards for Industrial Controls and Systems (ICS) and capable of carrying the specified current on a continuous basis.
4. Solid-State Reduced Voltage - Starter shall be furnished with silicon controlled rectifiers (SCR) connected for starting and include a bypass contactor. When operating speed is reached, the bypass contactor shall be energized removing the SCRs from the circuit during normal running. The starter shall be coordinated with the chiller package(s) making certain all terminals are properly marked according to the chiller manufacturer’s wiring diagrams.
5. The starter shall be equipped with a redundant motor control relay (MCR). The relay shall interconnect the starter with the unit control panel and directly operate the main motor contactor. The MCR shall constitute the only means of energizing the motor starter.
6. The main contactors shall have a normally open auxiliary contact rated at 125VA pilot duty at 115 VAC. An additional set of normally open contacts shall be provided on the MCR.
7. There shall be electronic overloads in each phase, which will permit continuous operation at 107 percent of the rated load amps of each motor. The overloads shall have a must-trip setting of 125 percent of the rated load amps. Overloads shall be manual reset and shall de-energize the main contactors when the over current occurs. The overloads shall be adjustable, have manual reset, be ambient compensated, and set for Class 10 operation.
8. Each starter shall have a current transformer and adjustable voltage dropping resistor(s) to supply a 5.0 VAC signal at full load to the unit control panels.
9. Each starter shall be equipped with a line-to-115 VAC control transformer, fused in both the primary and secondary, to supply power to the control panels, oil heaters and oil pumps.
10. Each starter shall have undervoltage, and phase failure and phase reversal protection

E. Variable Frequency Drive: Chiller shall be equipped with a Variable Frequency Drive (VFD) to automatically regulate compressor speed in response to cooling load and compressor pressure lift. The chiller control shall coordinate compressor speed and guide vane position to optimize chiller efficiency.

1. General:

a. A digital regulator shall provide V/Hz control.

b. The VFD shall have 110 percent continuous overload of continuous amp rating with no time limit, PWM (pulse width modulated) output, IGBT (insulated gate bipolar transistors) power technology, and full power rating at 2kHz.

c. Heat producing devices shall be contained in a single heat sink with single inlet and out connections for the connection of chilled water. When factory mounted on the chiller package, the water connections shall be piped and leak tested at the factory.

2. Main Control Relays

a. A motor control relay shall be provided to interlock the starter with the chiller. The relay shall constitute the only means of energizing the motor starter. No other devices (manual or automatic) with the capability of energizing the starter can be used. The starter is to be controlled by the unit microprocessor.

3. Motor Protection and Overloads

a. The starter shall include overload protection functions. These controls include:

1) Solid state overload (over current) protection.

2) Phase unbalance protection.

3) Phase reversal and phase loss protection.

4) Adjustable overload to closely match motor performance.

5) Three current transformers to measure motor current and a fourth current transformer for input to the chiller microprocessor.

4. Undervoltage (UV) Relay: The undervoltage relay is an adjustable three-phase protection system that is activated when the voltage falls below a predetermined safe value and is factory set at 85 percent of nominal.

5. Control Voltage Transformer: The starter is to be provided with a 3KVA control transformer with both secondary and primary fuses to supply control power to the chiller.

6. Additional Standard Components

a. Mechanical type solderless connectors to handle wire sizes indicated by the NEC.

b. Three vertically mounted current limiting power fuse blocks (fuses included).

c. Magnetic three-pole, vacuum break contactor.

d. Single phase control circuit transformer.

e. Vertically mounted control circuit primary current limiting fuses.

f. Current transformers.

g. Control circuit terminal blocks and secondary fuses.

h. Phase failure and reversal relay.

F. CHILLER CONTROLLER:

1. The chiller shall have distributed control consisting of a unit controller, a compressor controller and a 15-inch super VGA color touch screen for operator interface with the control system.

2. The touch screen shall have graphics clearly depicting the chiller status, operating data, including water temperatures, percent RLA, water set point, alarm status and have STOP and AUTO control buttons.

3. The operator interface touch screen shall have inherent trend logging capabilities, which are transferable to other PC management systems such as an Excel spreadsheet via a USB port. Active trend logging data shall be available for viewing in 20 minute, 2 hour or 8 hour intervals. A full 24 hours of history is downloadable via a USB port. The following trended parameters shall be displayed:

* + 1. Entering and leaving chilled water temps.
    2. Entering and leaving condenser water temps.
    3. Evaporator saturated refrigerant pressure.
    4. Condenser saturated refrigerant pressure.
    5. Net oil pressure.
    6. Percent rated load amps.

4. In addition to the trended items above, other real-time operating parameters are also shown on the touch screen. These items can be displayed in two ways: by chiller graphic showing each component or from a color-coded, bar chart format. At a minimum, the following critical areas must be monitored:

1. Oil sump temperature.
2. Oil feed line temperature.
3. Evaporator saturated refrigerant temperature.
4. Suction temperature.
5. Condenser saturated refrigerant temperature.
6. Discharge temperature.
7. Liquid line temperature.

5. Unit setpoints shall be viewable on screens and changeable after insertion of a password.

6. Complete unit operating and maintenance instructions shall be viewable on the touch screen and be downloadable via an onboard USB port.

7. Automatic corrective action to reduce unnecessary cycling shall be accomplished through pre-emptive control of low evaporator or high discharge pressure conditions to keep the unit operating through ancillary transient conditions.

8. Optional building automation (BAS) interface:

a. Factory mounted DDC controller(s) shall support operation on a BACnet, Modbus, or LonMarks network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier.

1) BACnet MS/TP master (Clause 9).

2) BACnet IP, (Annex J).

3) BACnet ISO 8802-3, (Ethernet).

4) LonMarks FTT-10A. The unit controller shall be LonMarks certified.

b. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

c. eXternal Interface File (XIF) shall be provided with the chiller submittal data.

d. Communication from the chiller unit controller as specified in the points list shall be via standard BAC net objects. Proprietary BACnet objects shall not be allowed. BAC net communications shall conform to the BACnet protocol (ANSI/ASHRAE 135). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.

**2.04 MISCELLANEOUS ITEMS**

1. Pump out System: The unit shall be equipped with a pump out system complete with a transfer pump, condensing unit, and storage vessel constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, and shall bear the National Board stamp. If the design of the unit allows the charge to be transferred to and isolated in the main condenser, then a pumpout system is not required. Transfer of refrigerant charge shall be accomplished by main compressor operation, migration, or gravity flow. Isolation shall be accomplished with valves located at the inlet and outlet of the condenser. The main condenser shall be sized to contain the refrigerant charge at 90°F according to ANSI/ASHRAE 15.
2. Purge System (Negative Pressure Chillers Only):
3. The chiller manufacturer shall provide a separate high efficiency purge system that operates independently of the unit and can be operated while the unit is off. The system shall consist of an air-cooled condensing unit, purge condensing tank, pumpout compressor and control system.
4. A dedicated condensing unit shall be provided with the purge system to provide a cooling source whether or not the chiller is running. The condensing unit shall provide a low purge coil temperature to result in a maximum loss of 0.1 pounds of refrigerant per pound of purged air.
5. The purge tank shall consist of a cooling coil, filter-drier cores, water separation tube, sight glass, drain, and air discharge port. Air and water are separated from the refrigerant vapor and accumulated in the purge tank.
6. The pumpout system shall consist of a small compressor and a restriction device located at the pumpout compressor suction connection.
7. The purge unit shall be connected to a 100 percent reclaim device.

C. Vacuum Prevention System (negative pressure chillers only): Chiller manufacturer shall supply and install a vacuum prevention system for each chiller. The system shall constantly maintain 0.05 psig inside the vessel during non-operational periods. The system shall consist of a precision pressure controller, two silicon blanket heaters, a pressure transducer, and solid-state safety circuit.

D. Refrigerant Detection Device (negative pressure chillers only): Chiller manufacturer shall supply and install a refrigerant detection device and alarm capable of monitoring refrigerant at a level of 10 ppm.

E. Waffle type vibration pads for field mounting under unit feet.

F. Start-up and Training: Provide start-up and customer training for the supplied equipment. The chiller manufacturer shall provide a factory-trained representative to perform the start-up and training. After startup provide a period of instruction not to exceed 40 hours to instruct the owner's personnel in the proper operation and maintenance of the chiller.

**PART 3 – EXECUTION**

**3.01 INSTALLATION**

A. Install equipment as indicated on Drawings and in compliance with manufacturers’ recommendations, with vibration isolation, mounting pads or foundations as may be required and flexible connectors as specified herein or in related Sections.

B. Inspect areas under which Work of this Section will be performed. Correct conditions detrimental to proper and timely completion of Work. Do not proceed until unsatisfactory conditions have been corrected.

1. Provide for connection of electrical wiring between starter and chiller control panel.
2. Arrange piping for easy dismantling to permit tube cleaning without disturbing piping.
3. Install pressure relief system in compliance with governing regulations to vent refrigerant in case of over pressurization. Provide piping from chiller pressure relief system or rupture disc to outdoors. Size as determined per ASHRAE 15.
4. Provide emergency shutoff switch at each entrance to the chiller room to shut down all equipment in chiller room and a separate switch for emergency exhaust of the room in accordance with code provisions.
5. Coordinate electrical requirements with Division 26 prior to ordering. Report any discrepancies to the Architect for resolution.

**3.02 EQUIPMENT FOUNDATIONS**

A. Equipment foundations, where indicated, shall be of sufficient size and weight and of proper design to preclude shifting of equipment under operating conditions, or under abnormal conditions which could be imposed upon equipment. Foundations shall meet requirements of equipment manufacturer, and when required by the Architect, obtain from equipment manufacturer approval of foundation design and construction for equipment furnished. Equipment vibration shall be maintained within the limits as required by the manufacturer.

**3.03 EQUIPMENT DESIGN AND INSTALLATION**

A. Uniformity: Unless otherwise specified, equipment of same type or classification shall be product of same manufacturer.

B. Application: No equipment shall be installed in an application or in such a manner that is not recommended by the manufacturer.

C. Design: Equipment shall be designed in accordance with applicable ASME, UL, or other required technical standards.

1. Pressure vessels shall be ASME Boiler and Pressure Vessel Code, Section VIII, construction and shall be so stamped.

D. Equipment Installation: Equipment installation shall be strictly in accordance with these Specifications, and installation instructions of manufacturers. Equipment installed on concrete foundations shall be grouted before piping is installed. Piping shall be installed in such a manner as not to place a strain on any equipment. Flanged joints shall be provided and adequately extended before installation. Piping shall be graded, anchored, guided and supported, without low pockets.

1. Install equipment properly aligned, leveled, and adjusted for satisfactory operation.

2. Install equipment so connecting and disconnecting of piping and accessories can be readily accomplished, and so those parts are easily accessible for inspection, service, and repair.

E. Refrigerant Gas Detection system Installation: Equipment installation shall include maintenance free, solid-state, electronic refrigerant gas detectors located strategically throughout the refrigeration machine room.

1. Install equipment properly aligned, leveled, and adjusted for satisfactory operation.

2. Install low-voltage conduit and wire.

3. Line voltage conduit and wire are specified in Division 26: Electrical.

4. Refrigerant gas detection system shall include maintenance-free, solid-state, electronic refrigerant gas detectors located strategically throughout the refrigeration plant room. Each detector shall cover a maximum area of 5,000 square feet.

5. The refrigerant gas detection and fan control system shall be provided for monitoring the refrigerant levels in the refrigeration plant room.

6. Manufacturer or manufacturer's representative shall review and test the system after it is complete and operating and shall submit report of test to the OAR.

**3.04 NOISE AND VIBRATION**

A. Operation of Equipment: Mechanical equipment and piping systems shall operate at lowest vibration and noise levels possible.

B. Corrective Measures: If objectionable noise and vibration occur, provide necessary or required changes to furnish satisfactory results.

**3.05 MANUFACTURER’S FIELD SERVICES**

* 1. Manufacturer shall furnish a factory trained service engineer without additional charge to start the unit(s). Representatives shall provide leak testing, evacuation, dehydration, and charging of the unit(s). Chiller manufacturers shall maintain service capabilities no more than 100 miles from the jobsite.
  2. A start-up log shall be furnished by the manufacturer to document the chiller’s start-up date and shall be signed by the owner or his authorized representative prior to turn over of the chillers.
  3. Provide a minimum of eight hours of factory training at a time selected by the Owner which is to be videotaped. Provide the Owner with two copies of the videotape.

**3.06 FIELD TESTS AND INSPECTION**

A. Perform field inspections, field tests and trial operations as spe­cified in Section 23 0500: Common Work Results for HVAC. Provide labor, equipment and incidentals required for testing. The Project Inspector will witness field tests and trial operations as specified in Section 23 0500: Common Work Results for HVAC.

B. Equipment and Material: Equipment and material certified as having been successfully tested by manufacturer, in accordance with referenced Specifications and standards, will not require re-testing before installation. Equipment and material not tested at place of manufacture will be tested before or after installation, as applicable, or where required to determine compliance with Specifications and standards.

C. Start-Up and Operational Test: System shall be started up and ini­tially operated with all components operating. During this time, various strainers shall be periodically cleaned until no further accumulation of foreign material occurs. Exercise care to ensure that minimum loss of water occurs when strainers are cleaned. Adjust safety and automatic control instruments as necessary to provide proper operation and sequence. Refer to Section 23 0500: Common Work Results for HVAC.

D. Extent of Field Tests: After installation and before Substantial Completion, Work of this Section shall be subjected to required field tests, including those specified, and listed in Section 23 0500: Common Work Results for HVAC.

E. Operation and Maintenance Data: Provide required operation and maintenance data as specified in Section 23 0500: Common Work Results for HVAC.

**3.07 PROTECTION**

A. Protect the Work of this Section until Substantial Completion.

**3.08 CLEANUP**

A. Remove rubbish, debris, and waste materials and legally dispose of off the Project site.

END OF SECTION