

SECTION 15720

CENTRAL STATION AIR HANDLING UNITS

**PART 1 –GENERAL**

1.1 SUMMARY

- A. Packaged and Custom Air Handling Units

1.2 RELATED WORK

- A. Provide temporary heating, cooling, and ventilating as needed.

1.3 REFERENCES

- A. ARI 430 - Standard for Central Station Air Handling Units
- B. NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- C. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- D. SMACNA - HVAC Duct Construction Standards
- E. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils
- F. ANSI/UL 900 - Test Performance of Air Filter Units
- G. AMCA 300 - Reverberant Method for Sound Testing of Fans
- H. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices
- I. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement
- J. Occupational Safety and Health Administration (OSHA)

1.4 QUALITY ASSURANCE

- A. Air Handling Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product offering.
- B. Constant Volume Air Handling Units: Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. If air handling units are not certified in accordance with ARI 430, the Contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet capacities shall be the sole responsibility of the Contractor.
- C. Variable Air Volume Air Handling Units with Variable Speed Drives: Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. Certify units at full speed. If air handling units are not certified in accordance with ARI 430, the Contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the Contractor.
- D. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-87.

1.5 SUBMITTALS

- A. Submit as-built drawings and product data.
- B. As-built drawings shall show total unit configuration in direction of airflow, unit dimensions, and field duct connection details.
- C. Product data shall indicate manufacturer, model, type, arrangement, coil max velocity, filter max velocity, fan data, airflow capacity, external static pressure, total static pressure, motor hp, fan max bhp, dimensions, weights, heating coil data: fin series, type, height, width, rows, capacity, air entering and leaving temperatures, air pressure drop, water entering and leaving temperatures, water pressure drop; cooling coil data: fin series, type, height, width, rows, capacity, air entering and leaving (dry bulb and wet bulb) temperatures, water flow, water entering and leaving temperatures, water pressure drop; motor electrical characteristics, finishes of materials, filter media, filter sizes, and filter quantities.
- D. Submit manufacturer's installation instructions.
- E. Provide fan curves with specified operating point clearly plotted. Fan curves shall indicate air volume, static pressure, fan speed and brake horsepower.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data.
- B. Include instructions for lubrication, filter replacement, motor and drive replacement, belt tension adjustments, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Each section shall have lifting lugs or shipping skid to allow for field rigging and final placement of section.
- B. Deliver units to site with fan motors, sheaves, and belts completely assembled and mounted in units.
- C. Store and protect products. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. All exposed openings will be sealed during storage and installation to avoid contamination. Units will be cleaned completely before start-up.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Do not put units into normal service until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

## PART 2 – PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Trane
- B. McQuay
- C. Carrier
- D. Hunt Air
- E. or equal

### 2.2 GENERAL

- A. Manufacturer must clearly define any exceptions made to Plans and Specifications. Mechanical Contractor is responsible for expenses that occur due to exceptions made.
- B. Fabricate draw-through type air handling units with fan section, coil sections, access sections, mixing box, filter sections, discharge plenum.
- C. Factory fabricate air handling units of sizes, capacities, and configurations as scheduled drawings.
- D. Provide safety platform if air handling unit is installed greater than or equal to 3 feet from the finished roof or floor level per OSHA requirements.

### 2.3 CASING

- A. Construct casings of minimum 16 gauge G90-u galvanized steel structural frame and base. Construct double wall panels of minimum 18 gauge G90-u galvanized steel exterior panels. In order to properly clean and service the interior of the air handler, the casings shall be constructed such that structural frames are free standing and double wall panels are non-load bearing. Contractor shall be responsible to provide connection flanges and all other framework that is needed on unit to ensure that removal of unit's double wall panels shall not affect structural integrity of unit.
- B. Construct casing sections located upstream of supply fan for operation at 4 inches water gage negative static pressure and casing sections located downstream of supply fan for operation at 6 inches water gage positive static pressure. Seal joints between casing sections with closed- cell foam gasketing for leak seal and thermal and acoustical break.
- C. Provide access sections with doors between all internal components to ensure access and cleanability of the air handler.
- D. Casings not constructed of G90-U galvanized steel, casings with welds on exterior surfaces, or casings with welds on interior surfaces that have burned through to exterior surfaces shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel in order to prevent premature corrosion and microbial growth.
- E. Casing shall have removable full size access panels or double wall doors as scheduled on drawings. Construct access doors of minimum 18 gauge G90-U galvanized steel exterior panels and minimum 22 gauge perforated G90-U galvanized steel interior panels.

- F. Provide automotive style neoprene gasketing around full perimeter of access doors to prevent air leakage.
- G. Provide "ventlock" style non-corrosive alloy latches operable from the inside or outside of unit. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement. Insulate access doors with 2" thick 1-1/2 lb per cubic foot density matt faced fiber glass insulation.
- H. Insulate casing sections with 2" thick 1-1/2 pound per cubic foot density matt faced fiber glass insulation. Provide double wall casing construction and encase insulation between exterior and interior casing panels such that no insulation is exposed to airstream. Foil facing on insulation is not acceptable as alternate to double wall construction. Insulate all structural channels connected to casing panels and cover openings in structural channels with galvanized steel. Insulation shall comply with NFP-90A.
- I. Provide sealed double wall drain pans constructed of minimum 18 gauge; cross break interior pans and pitch toward drain connections to ensure complete condensate drainage. Units with cooling coils shall have drain pans under complete galvanized steel exterior pans and 304 stainless steel interior pans. Encase manufacturer's standard insulation between exterior and interior walls. Drain pans shall be sloped in cooling coil section. All drain pan connections will be to the side of the unit to enable proper trapping.

#### 2.4 FANS

- A. Supply, return and exhaust fan sections (not including fume exhaust fans) with Forward curved (FC) Backward incline (BI) or Air Foil (AF) will be double width, double inlet centrifugal fan designed and suitable for class of service indicated in the unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping.
- B. Supply, return and exhaust fan sections with AF single width, single inlet centrifugal plug fans designed and suitable for class of service indicated on unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet specifications. Key fan wheels to fan shaft to prevent slipping.
- C. Fanwall: When selected the Fanwall system shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, (Class I, II, or III). All fans shall be selected to deliver the specified airflow quantity at the specified operating total static pressure and specified fan/motor speed. The Fanwall array shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor "cube" shall include an 11 gauge, A60 Galvanized steel intake wall, 14 gauge spun steel inlet funnel, and an 11 gauge G90 galvanized steel motor support plate and structure. The fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. All motors shall be standard pedestal mounted type, premium efficiency, T-frame motors selected at the specified

operating voltage, RPM as scheduled. All motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance. The Fanwall array shall be provided with acoustical silencers that reduce the bare fan discharge sound power levels by a minimum of 15 db re  $10^{-12}$  watts throughout the eight octave bands with center frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 HZ when compared to the same unit without the silencers. The silencers shall not increase the fan total static pressure, nor shall it increase the airway tunnel length of the air handling unit when compared to the same Fanwall unit without the silencer array.

- D. Provide self-aligning, grease lubricated heavy duty sealed or pillow-block roller bearings selected for L-50 200,000 hour average life per ANSI/AFBMA 9. For pillow-block type bearings extend grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to casing.
- E. Mount fans on minimum 16 gauge steel isolation bases. Internally mount motors on same isolation bases and internally isolate fans with 2 inch spring seismic isolators. Install a flexible connection between fan and casings to ensure proper isolation.
- F. Fan sections shall have full height, double wall, hinged, removable access doors on both sides for inspection and maintenance of internal components. To facilitate inspection of internal components, provide 8 x 10 inch sealed glass and wire view windows on access doors and provide marine lights inside fan sections. Construct marine lights of sealed glass fixtures with wire guards to keep electrical sockets dry and protect fixtures from damage. Provide moisture proof T-8 florescent light with timer switch for any fan taller than five feet.
- G. Weigh fan and motor assembly at AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section assemblies include fan wheels, shafts, bearings, drives, belts, isolation bases and isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM's as scheduled on drawings. For fan sections controlled by variable frequency drives, balance at all speeds between 25% and 100% of design RPM.

## 2.5 MOTORS

- A. Factory install all motors on slide base to permit adjustment of belt tension.
- B. Fan Motors shall be heavy duty, high efficiency TEFC up to 5 hp. Motors greater than 5 hp shall be premium efficiency US841, or approved equal, designed for VFD motor slide base, starter and belt guard. Motors shall be operable at 480 Volts(when available), 60 Hz, 3-phase.

## 2.6 COILS

- A. Coils shall be manufactured by the same company as the supplier of the air handling unit. Install coils such that headers and return bends are enclosed by unit casings.
- B. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

- C. Construct coil casings of minimum 16 galvanized steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through air stream.
- D. Water Cooling Coils
  - 1. Clearly label supply and return headers on outside of units such that direction of coil water-flow is counter to direction of unit air-flow.
  - 2. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
  - 3. Construct headers of round copper pipe or cast iron.
  - 4. Construct tubes of 5/8 inch O.D. minimum 0.020 inch thick copper and construct fins of aluminum.
  - 5. Coils shall be selected for a delta T of 15 F or greater.
  - 6. Provide corrosion resistance with Blue Fin, Electro-Fin, Heresite, or equal coating.
- E. Water Heating Coils
  - 1. Clearly label supply and return headers on outside of units such that direction of coil water-flow is counter to direction of unit air-flow.
  - 2. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
  - 3. Construct headers of round copper pipe or cast iron.
  - 4. Construct tubes of 5/8 inch O.D. minimum 0.020 inch thick copper and construct fins of aluminum.
  - 5. Install HHW coils upstream from CHW coils for freeze protection.
  - 6. Provide corrosion resistance with Blue Fin, Electro-Fin, Heresite, or equal coating.
- F. Steam Heating Coils
  - 1. Clearly label supply and return connections on outside of units.
  - 2. Provide non-freeze steam distributing type coils. Pitch steam coils in units for proper drainage of steam condensate from coils.
  - 3. Proof test coils to 300 psig air under water and leak test coils to 200 psig air pressure underwater
  - 4. Construct headers of cast iron or round copper pipe.
  - 5. Construct tubes of 5/8 inch O.D. minimum 0.020 inch thick copper. Construct fins of aluminum.
  - 6. Inner tubes shall have orifices that ensure even steam distribution across coil face. Direct orifices toward return connections to ensure steam condensate is discharged from coils.
  - 7. Provide corrosion resistance with Blue Fin, Electro-Fin, Heresite, or equal coating.

## 2.7 FILTERS

- A. Filters shall be 24"x24"x12, rigid type, and 90% efficient.
- B. Holding Frame Assemblies: Filter holding frames shall be of type 6063-T aluminum, or 304 stainless steel. Holding frames shall be upstream accessible. They shall be equipped with polyurethane foam gaskets, fasteners and filter centering dimples. Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. Holding frame assemblies shall be sized for less than or equal to 500 fpm face velocity.

- C. Magnehelic Filter Gauge: A differential pressure gauge for measuring the pressure drop across each filter bank shall be installed. The gauge shall be diaphragm-actuated dial type 4-3/4 inch O.D., with white dial, black figures and graduations and pointer zero adjustment. Outdoor units shall have the gauge enclosed in a protective sheet metal box with a hinged inspection door.

## 2.8 DAMPERS

- A. Manufacturers: Ruskin, Johnson Control, Honeywell. Pneumatic actuators by Johnson Control, Honeywell. Electric Actuators by Belimo, Honeywell, or Johnson Control.
- B. Outside air, return air or exhaust air dampers will be internally mounted low leakage type. Dampers will be double-skin airfoil design or equivalent. Construct damper blades of minimum 14 gauge galvanized steel and damper frames of minimum 16 gauge galvanized steel. Provide opposed blade action with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings with stainless steel drive shaft. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 5 CFM/square foot at one inch water gage and 9 CFM/square foot at 4 inches water gage. All Leakage testing and pressure ratings will be based on AMCA Publication 500.
- C. Face and bypass dampers will be low leak as scheduled on drawings. Dampers will be double skin airfoil design. Construct damper blades of minimum 14 gauge galvanized steel and damper frames of minimum 16 gauge galvanized steel. Provide opposed blade action with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings with stainless steel drive shaft. Mechanically link face dampers to bypass dampers and provide end driven control shafts. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 5 CFM/square foot at one inch water gage and 9 CFM/square foot at 4 inch water gage.
- D. Multi-zone dampers will be double skin airfoil design or equivalent. Construct damper blades of minimum 14 gauge galvanized steel and damper frames of minimum 16 gauge galvanized steel. Dampers shall have metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings with stainless steel drive shaft. Leakage rate shall not exceed 11 CFM/square foot at one inch water gage.
- E. Pneumatic actuators shall have pilot positioner.

## 2.9 AIRFLOW MEASUREMENT STATION

- A. Provide solidstate electronic air measurement system (EAMS) as specified on schedule and drawings. Contractor is responsible for mounting EAMS in strict accordance with manufacturer's recommendations. EAMS station shall be capable of functioning accurately between -20 degrees F and +158 degrees F and have the ability to transmit a 2-10 Vdc linear signal representative of velocity. The measurement system shall be factory calibrated with a total accuracy of +/- 5% of actual flow down to 15% of the nominal flow. Total EAMS accuracy shall include and depend upon: temperature, compensation, humidity, repeatability, turbulence and placement. If required, field assembly and field calibration of the airflow measurement stations shall be the responsibility of the installing Contractor.



## 2.10 ACCESS SECTIONS

- A. Access sections shall have double wall, hinged, removable access doors on both sides of sections. To facilitate inspection of internal components, provide 8 x 10 inch sealed glass and wire view windows on access doors and provide marine lights inside fan sections. Construct marine lights of sealed glass fixtures with wire guards to keep electrical sockets dry and protect fixtures from damage.
- B. Construct access sections such that access may be obtained to internal components through any access panel. Construct panels of minimum 18 gauge galvanized steel. In order to properly clean and service the interior of the air handler, the casings shall be constructed such that structural frames are free standing and double wall panels are non-load bearing. Contractor shall be responsible to provide connection flanges and all other framework that is needed on unit to ensure that removal of double wall panels shall not affect structural integrity of unit.

## 2.11 GENERAL MODULES

- A. Air Blender: A Blender Product's air blender shall be supplied and installed by the AHU manufacturer to provide mixing of air and to decrease the possibility of air stratification. Construct blender of 0.080" 3003 aluminum. Double wall access doors shall be provided on both sides of section.
- B. Diffuser Module: Provide a diffuser module to promote equal air distribution across coils and filters.
- C. Economizer: Provide return, outside air, and exhaust dampers and controls for a fully functional 100% outside air economizer cycle.

## 2.12 MOTOR STARTER AND FUSIBLE DISCONNECT (CONSTANT VOLUME APPLICATIONS)

- A. Provide NEMA Type Combination Starter/Disconnects for each fan motor. Starter/disconnect shall be Allen Bradley or equal. Each starter/disconnect shall be properly sized, mounted, wired and commissioned by the AHU manufacturer. Starter/disconnect shall include fusible disconnects with fuses (UL listed time delay class RK1 fuses for type "2" short circuit coordination), control transformer (with primary and secondary fusing, and secondary grounding), Hands-Off-Auto (HO-A) switch, two N.O. auxiliary contacts, overload heaters and manual reset overload relays. Units with factory mounted controls shall also include power wiring from the starter control transformer to the control system transformers, and start-stop wiring from the direct digital controller start-stop relay to the starter H-O-A switch. Wiring methods must comply with the National Electric Code and NFPA 70.
- B. ENCLOSURE: Starters/disconnects shall have full metal enclosures with welded seams. All welds shall be properly finished with no rough edges. Enclosures must have a phosphate prepaint treatment and a durable enamel hard finish. The door shall be removable for ease of wiring and service.
  - 1. Starter/disconnects shall be supplied with NEMA Type 12 Enclosures. This enclosure is intended for indoor use primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids. They shall meet drip, dust, and rust resistance tests. They are not intended to provide protection against conditions such as internal condensation. NEMA type 12 will only be used in rooms with filtered air.



2. Starter/disconnects shall be supplied with NEMA Type 4 Enclosures. This enclosure is intended for indoor or outdoor use primarily to provide degree of protection against windblown dust and rain, splashing water, and hose directed water; and to be undamaged by the formation of ice on the enclosure. They shall meet hose down, dust, external icing, and rust resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing. Enclosures shall be made of heavy gauge stainless steel. Covers shall have synthetic rubber gaskets.
  - C. FACTORY MOUNTING: Starter/disconnects shall be factory mounted externally on the drive side (units w/o factory mounted controls) or on the front (units w/ factory mounted controls) of the air handling unit fan section. Ensure four feet of mechanical room clearance in front of the starter for serviceability. The panels shall be braced as necessary to properly support the starter/disconnect assembly during shipment.
  - D. FACTORY COMMISSIONING: Trained factory personnel shall ensure proper operation of the starter by a thorough factory test. Units should be energized through factory test. Units should be energized through the "Hand" position, as well as the "Auto" position when factory mounted controls are available. RK1 type "2" fuses and overload heaters must be selected individually for the voltage, horsepower, and full load amps of the actual motor being supplied.
- 2.13 VARIABLE FREQUENCY DRIVES (VARIABLE SPEED APPLICATIONS)
- A. Provide a variable frequency drive (VFD) on air handling unit fans as scheduled. Refer to the Variable Frequency Drive section in the Electrical Facilities Design Guidelines.
- 2.14 CONTROLS
- A. DDC CONTROLLER: A dedicated stand-alone DDC programmable control module shall be provided with each AHU. Control of more than one unit from a controller is not acceptable. This will ensure that a controller failure will not affect more than one AHU.
  - B. UNIT MOUNTED DISPLAY AND KEYPAD: Each controller shall have an LCD screen and keypad for user interface mounted on the unit it is controlling. System passwords are required to prevent unauthorized use. A portable service tool is acceptable, but one must be permanently mounted at each AHU. Local access to AHU status, set points, and alarms is critical. No exceptions will be permitted.
  - C. FACTORY MOUNTING: The controller and a majority of the control components shall be selected, mounted, wired, and tested by the AHU manufacturer. Unit mounted controls shall be covered by the AHU manufacturer's standard warranty of one year from AHU startup or 18 months from shipment, whichever comes first. Factory mounting will facilitate temporary heating, cooling, ventilation, and/or timely completion of the project. Field installed systems are acceptable with the engineer's approval of actuators, valves, sensors, and control drawings prior to bid day.
  - D. PROGRAM MEMORY BACKUP: All programming required for operation shall be retained in permanent memory. Battery backup for a minimum of 72 hours is also permissible.

- E. **MANUAL RESET LOW LIMITS AND AVERAGING SENSORS:** A manual reset low limit switch with a 20 foot element for each 25 square feet of coil area will shut down the fan, close the outside air damper, and open the heating valve to protect the unit. The low limit switches shall be factory mounted to maximize coil coverage. Field installation will be acceptable if the proper capillary clips are used and all four corners of the coil and the coil face are uniformly protected. Averaging sensors must be installed with the same quality procedures across the coil face.
- F. **BUILDING AUTOMATION SYSTEM:** The Programmable Control Module shall be fully compatible with a Building Automation System. Complete communications and diagnostics including all AI, BI, AO, BO, set points, and alarms shall only require a twisted pair of wires. System optimization strategies shall be available to perform such energy management functions as resetting duct static downward until one VAV box is fully open, and resetting chilled water temperature upward until one valve is fully open. Air handling unit controls shall be tied to the campus wide EMCS for monitoring and remote adjustments.

### **PART 3 – EXECUTION**

#### **3.1 INSTALLATION**

- A. Install in strict accordance with manufacturer's requirements, shop drawings, and Contract Documents.
- B. Adjust in alignment on concrete foundations, sole plates or other supporting structure. Level, grout, and bolt in place.
- C. Coordinate AHU electrical installation with Division 16 (26) - Electrical.
- D. Coordinate AHU controls with control contractor.
- E. Provide all appurtenances required to ensure a fully operational and functional system.

#### **3.2 START-UP**

- A. **Factory Start-Up Services:** Start-up is to be supervised by the unit manufacturer or a manufacturer certified service organization. Physical connections and start-up are provided by the installing contractor. Provide for as long a period of time as is necessary to ensure proper operation of the unit but in no case for less than 2 full working days. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. The start-up engineer shall submit a written report to the Owner's Representative and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.
- B. **Operation and Maintenance Manuals:** Provide complete with descriptive literature, model, and serial number of all equipment, performance data, manufacturer's instructions for operating and maintenance, lubrication recommendation and schedule, and winter shutdown procedure.

END OF SECTION