SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section supplements all Sections of this Division and shall apply to all phases of Work required to provide for complete installation of mechanical system. Intent of this specification is to provide complete and fully functional mechanical system.

1.2 QUALITY REQUIREMENTS

A. General Requirements.

1. All Mechanical Work performed under this Division shall be installed by competent craftsmen, skilled in the trade involved, and shall be installed in conformance with all applicable local codes.
2. Installation of all items shall be performed in strict accordance with all codes and regulations set forth by State, including CALGreen Tier 1 requirements, as well as Local, and Federal authorities.

B. Requirements of Regulatory Agencies:

1. Codes and Ordinances.
   a. All Work shall meet the requirements of local codes, ordinances, and utility companies except adhere to the Contract Documents when more strict requirements are specified.
   b. Codes which govern mechanical Work in this Project are as follows:
      1) ASME Boiler Code
      2) NFPA Life Safety Code l0l
      3) NFPA 90A
      4) NFPA l3
      5) Factory Mutual Standards
      6) American Gas Association
      7) California State Fire Marshal Regulations.
2. Manufacturer's Tests. All materials shall, so far as possible, be subjected to standard tests by the manufacturer before shipment.

1.3 SUBMITTALS

A. Shop Drawings and Product Data:

1. General requirements for all shop drawings are specified elsewhere in these specifications. Check individual sections for any specific submittal requirements.

B. Operation and Maintenance Data:

1. Maintenance Manuals.

   a. Furnish two sets of maintenance manuals, each containing items specified below. Furnish manuals to LAWA before final acceptance of the mechanical Work.

   b. Definitions Applicable to the Maintenance Manuals.

      1) Literature. Any page (either whole or in part), sheet, drawing, or booklet describing the maintenance, operation, and parts of mechanical equipment, which is furnished either in the shipping carton, attached to the equipment, or otherwise prepared and distributed by the manufacturer for the user, not limited to papers submitted as shop drawings.

      2) Mechanical Equipment. All major items shown in the Mechanical Division Drawings and Work for which shop drawings are requested except the following: thermometers, expansion tanks, air separating tanks, insulation materials, vibration isolation equipment, plumbing drains and fixture carriers, and boiler stack.

      3) Instructions. An outline written by the Contractor with information necessary to help LAWA apply the maintenance manual and simplify verbal instructions.

   c. Collection of "Literature." Collect "literature" in like new condition, of all pieces of "mechanical equipment" until two copies of each are obtained. Copies soiled during construction will not be accepted.

   d. Assembly of "Literature."

      1) Assemble "literature" in separate, multiples of two, 3-ring loose leaf binders, 2 inches (50 mm) size, with chrome-plated piano hinges and black hard coated covers.

      2) Small or large "literature" not easily inserted in binders shall each be put in heavy manila envelopes.

      3) Furnish each binder with plastic enclosed tabs on reinforced paper neatly arranged. Type each of the following on a separate tab.

         a) Instructions
         b) Valve Charts
         c) Accessories
         d) Lubrication
         e) Testing and Balancing Reports
         f) Each Specification and Title in the Project Specification for which "Literature" has been collected.

      4) File "instructions" envelopes and "literature" under correct tabs. Clearly identify each piece of "literature" and envelope with equipment name and numbers.

   e. Valve Charts.

      1) Format. Arrange format of valve charts by rooms and sequence all valve numbers starting with mechanical equipment rooms and finishing with "occupied spaces."

2) Information. Furnish the following information typed on valve charts for each valve furnished throughout the Project in the Mechanical Division, except check valves and automatic valves.

a) Room numbers and name where valve is located, i.e. "ZG boiler room."

b) Valve number assigned by Contractor and stamped on brass plate, i.e. "l47."

c) Service medium using designation assigned to Drawings on mechanical symbols, i.e. "heating hot water supply" or "plumbing cold water."

d) Valve types as specified herein.

e) Function valve serves, i.e. "strainer shut-off" or "balancing valve."

f) Zone identification, i.e. "AHU-2" or "auxiliary heating."

3) Insert Charts in Manuals.

f. Lubrication Charts. Furnish a chart listing each lubricated piece of equipment, the proper type of oil or grease required, and recommended frequency of lubrication. Insert charts in manuals.

g. Accessories.

1) Furnish LAWA with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required, and manufacturer of the following items.

a) Filters

b) Fan Belts

c) Refrigerant Dryers

2) Insert Schedules in Manuals.

h. Insert 2 copies each of correct testing and balancing reports in manuals.

2. Instructions in Operation.

a. After all tests and adjustments have been made and the maintenance manual has been completed and given to LAWA, furnish one or more full-time qualified personnel as necessary to put the mechanical Work in continuous operation for a period of not less than <u>two</u> days, during which time the designated personnel's only purpose shall be to give complete operating and maintenance instructions to LAWA.

1.4 JOB CONDITIONS

A. Existing Conditions:

1. Existing Pipe Lines.

a. If any existing water, gas, or other pipes and appurtenances are encountered which interfere with the proper installation of new Work and which will not be used in connection with new Work, or existing systems, close such pipe in a proper manner, and if necessary, move or remove the pipes as directed by LAWA.

b. Where existing Work is to be modified, it shall be done in conformance with the Specifications. Materials used shall be same as existing unless otherwise specified.

B. Sequencing, Scheduling:

1. Coordination of Work.

a. Plan all Work so that it proceeds with a minimum of interference with other trades. Inform the general Contractor of all openings required in the building construction for the installation of mechanical Work. Provisions shall be made for all special frames, openings, and pipe sleeves as required. The mechanical Contractor shall pay for all extra cutting and patching made necessary by his failure to properly direct such Work at the correct time.

b. Verify local utility company's inspection requirements and abide by their rights of inspection before covering or otherwise concealing any piping, wiring, or equipment.

PART 2 – PRODUCTS – Not Applicable.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Installation:

1. General.

a. Cooperate with all other Contractors in furnishing material and information for correct location, in proper sequence, of all sleeves, bucks, inserts, foundations, wiring, etc.

b. All piping connections to equipment shall be made with unions or flanges to permit dismantling. Flanges and unions shall also be installed in the piping systems to permit disassembly consistent with good installation practice and as required for removal of connected equipment from place of installation.

2. All belt drives, flexible couplings, and other exposed rotating or reciprocating parts shall be covered with OSHA approved safety covers. Covers shall be permanent type and easily removable.

3. All motors and bearings shall be covered with watertight and dust-proof covers during construction period.

4. Sleeves, frames, and wall pipes shall be furnished and installed for all pipes and ducts, passing through concrete floors and walls and shall be coordinated with other trades. Special sleeves through floors and walls shall be installed in accordance with manufacturers printed instructions and as detailed.

a. All sleeves and frames through exterior floors and walls above ground and all interior floors and walls shall be black iron pipe unless otherwise noted. Sleeves and frames shall be of a size to accommodate the pipe or duct and insulation.

Sleeves and frames shall be grouted in place with installation left smooth and finished to match surrounding surfaces.

b. Pipes passing through exterior floors and walls below ground, 3 inch (75 mm) and larger, shall utilize cast iron wall pipes unless noted or detailed otherwise. The wall pipe shall be used to convey the liquid or gas through the floor or wall without the use of sleeves. Wall pipes shall be furnished complete with end connections and adapters required to connect to the piping material. Size of wall pipe shall equal or exceed the maximum pipe size connected thereto. Wall pipes shall be integrally cast into floor or wall construction and provide the best possible seal at the exterior exposure.

c. Pipes passing through exterior floors and walls below ground, 2-1/2 inch (63 mm) and smaller, shall utilize black iron pipe sleeves as specified for aboveground in conjunction with a modular mechanical type seal as hereinafter specified.

1) The modular mechanical type seal shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. Tightening of the bolts shall cause the rubber sealing elements to expand providing a watertight seal between the pipe and wall sleeve.

2) The required inside diameter of the sleeve and the installation of the seal shall be coordinated with the seal manufacturer to provide a watertight joint. Seals shall be "Link Seal" manufactured by Thunderline Corporation. A seal consisting of a combination of a sleeve and a pressure clamping system manufactured by O. Z. Manufacturing is acceptable.

d. Cutting of openings and installation of sleeves and frames through exterior floors and walls above grade, and interior floors and walls shall be done in a neat, workmanlike manner. Openings shall be cut only as large as required for the installation.

1) At fire-rated floor and wall penetrations, provide penetration sealant as specified in herein.

e. Sleeves and frames at floors and walls in concealed locations and in unfinished spaces such as mechanical rooms, etc. shall extend 1 inch (25 mm) from the finished surface. All other sleeves at floors shall extend 1/4 inch (6 mm) from finished floor surface, but shall allow placement of escutcheons. All other sleeves at walls shall be installed flush with finished surface.

f. Escutcheons for exposed pipe through floors and walls, where exposed to view, shall be provided and shall be chromium plated except where special escutcheons are required under plumbing fixtures. Escutcheons shall be sized sufficiently to conceal the floor or wall opening and sleeve.

5. Interference.

a. Wherever piping runs on ceilings, arrange the run of the piping in such a manner that it does not interfere with grilles, light outlets or light fixtures.

6. Valves.
    a. Valves shall be provided on all piping wherever shown or specified using adapters where required. All removable or replaceable equipment shall be valved. All valves shall have a securely fastened stamped brass metal plate each bearing a different number identified in the maintenance manual.
7. Openings in Pipes.
    a. All openings in pipes shall be kept closed during the progress of the Work.
8. Lubrication.
    a. Provide all lubrication for the operation of all equipment until substantial completion of the Project. Run in all bearings, and after they are run in, drain and flush bearings and refill with a new oil change. Refer to maintenance manual specification for lubrication chart.

3.2 ADJUSTMENT AND CLEANING

A. Safety Devices. Thoroughly check all safety devices to assure proper operation and protection.

B. Service.
1. Perform service on all mechanical Work until the date of substantial completion including oiling and greasing, adjustments, cleaning, packing of seals, and other items as recommended by equipment manufacturer in the maintenance manual hereinbefore specified.
2. Air filters.
    a. Do not operate air moving equipment having air filters unless temporary filters are in place to protect the mechanical Work.
    b. Clean or replace these temporary filters before final test and balance Work is begun as necessary for accurate readings. After completing the testing and balancing Work, replace temporary filters with new filter media as specified.
3. Strainers.
    a. Remove, clean and reinstall each strainer screen as specified below after systems have been flushed as specified in other sections of Division 23.
        1) Clean each strainer after all adjustments have been made and system has operated a minimum of 24 hours, but before final test and balancing operation is started.
        2) Clean each strainer again, after final test and balancing operation and before substantial completion of the Project.
    b. Certain screens may remain out of the strainer body after removal during the final cleaning only as directed by the LAWA.
4. Purge all air from water systems after each servicing.
    a. Protect all furnishings and finishes during each servicing operation, and repair or replace to original condition, those damaged as a result of servicing.

5. Replace insulation removed or damaged after each operation. Leave insulation as specified herein.
6. Contractor may coordinate servicing operations with LAWA's operating personnel so as to coincide with time interval specified for instruction in operation.
7. Put system in full operating condition before substantial completion of the Project.

C. Alarms. Test and adjust alarms for satisfactory operation.

D. Tests and Adjustments. Upon completion of the installation and before substantial completion of the Project, the Contractor shall make all necessary tests and adjustments to place the system in a working condition. Systems shall be balanced as specified herein. The general operating tests shall cover a period of not less than 12 hours after completion of final testing and balancing, and shall demonstrate that the entire equipment is functioning in accordance with the Specifications. Furnish all instruments, test equipment, and competent personnel that are required for the tests.

END OF SECTION 23 05 00

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - DESCRIPTION

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and poly- phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on AC power systems up to 600V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

B. Section also includes the adjustable speed drive requirements.

C. Efficiency of the motors for the HVAC shall be in compliance with provisions of California Energy Code, Table 100-A and the latest edition of the Building Energy Efficiency Standards, Title 24.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1) Motor controllers.
2) Torque, speed, and horsepower requirements of the load.
3) Ratings and characteristics of supply circuit and required control sequence.
4) Ambient and environmental conditions of installation location.

PART 2 - MATERIALS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 104º F and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1, including applications of premium efficiency motors.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1) For motors with 2:1 speed ratio, consequent pole, single winding.
   2) For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
   1) Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2) Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1) Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2) Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3) Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4) Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 ADJUSTABLE SPEED DRIVES

A. Manufacturer: **Magna Drive** or approved equal.

B. Components:
1) Copper Conductor Rotor Assembly directly connected to the motor (input) shaft.
2) The Magnet Rotor Assembly and the Actuation Components are directly connected to the load (output) shaft. Magnets to be rare-earth type.
3) The ASD's output is controlled by an actuator. The actuator allows the process control signal to modulate the speed or torque output of the drive. Actuator to be 110 VAC with a 4 to 20 mA control signal.
4) Hubs and shrink discs.
5) Oil lubricated gear box and output shaft assembly.
6) Vertical applications to have oil lubricated thrust bearings with AFBMA 40,000 hour life and with 25,000 pounds of vertical down-thrust capacity

C. Suitable mounting kits shall be provided depending on mounting orientation (vertical or horizontal.

D. Connect power to meet application requirements.

2.6 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 HP shall be one of the following, to suit starting torque and requirements of specific motor application:
1) Permanent-split capacitor.
2) Split phase.
3) Capacitor start, inductor run.
4) Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 – EXECUTION (NOT USED)

END OF SECTION 23 05 13

SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flexible pipe connectors.
2. Expansion joints.
3. Flexible expansion loops.
4. Pipe alignment guides.
5. Pipe anchors.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B31.1 - Power Piping.
2. ASME B31.5 - Refrigeration Piping.
3. ASME B31.9 - Building Services Piping.
4. ASME Section IX - Boiler and Pressure Vessel Code - Welding and Brazing Qualifications.

B. American Welding Society:

1. AWS D1.1 - Structural Welding Code - Steel.

1.3 DESIGN REQUIREMENTS

A. Provide structural work and equipment required for expansion and contraction of piping. Verify anchors, guides, and expansion joints provide and adequately protect system.

B. Expansion Compensation Design Criteria:

1. Installation Temperature: 50 degrees F.
2. Hot Water Heating System Temperature: 210 degrees F.
3. Chilled Water: 40 degrees F.

1.4 SUBMITTALS

A. Shop Drawings: Indicate layout of piping systems, including flexible connectors, expansion joints, expansion compensators, loops, offsets and swing joints. Submit shop drawings sealed by a registered California Mechanical Professional Engineer.

B. Product Data:

1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.

C. Design Data: Indicate criteria and show calculations.

D. Manufacturer's Installation Instructions: Submit special procedures.

E. Provide Manufacturer's Certificate.

F. Manufacturer's Field Reports: Indicate results of inspection by manufacturer's representative.

PART 2 - PRODUCTS

2.1 FLEXIBLE PIPE CONNECTORS

A. Manufacturers:

1. Flexicraft.

2. Flex Hose.

3. Metraflex.

B. Steel Piping:

1. Inner Hose: Stainless Steel.
2. Exterior Sleeve: Double braided stainless steel.
3. Pressure Rating: 200 psig WOG and 250 degrees F.
4. Joint: As specified for pipe joints.
5. Size: Use pipe-sized units.
6. Maximum offset: 3/4 inch to 1 inch on each side of installed center line.

C. Copper Piping:

1. Inner Hose: Bronze.
2. Exterior Sleeve: Braided bronze.
3. Pressure Rating: 200 psig WOG and 250 degrees F.
4. Joint: As specified for pipe joints.
5. Size: Use pipe sized units.
6. Maximum offset: 3/4 inch on each side of installed center line.

2.2 EXPANSION JOINTS

A. Manufacturers:

1. Flexicraft.

2. Flex Hose.

3. Metraflex.

B. Stainless Steel Bellows Type:

1. Pressure Rating: 200 psig WOG and 250 degrees F.
2. Maximum Compression: 1-3/4 inch.
3. Maximum Extension: 1/4 inch.
4. Joint: As specified in for piping system.
5. Size: Use pipe sized units.
6. Application: Steel piping 3 inch and smaller.

C. External Ring Controlled Stainless Steel Bellows Type:

1. Pressure Rating: 200 psig WOG and 250 degrees F.
2. Maximum Compression: 15/16 inch.
3. Maximum Extension: 5/16 inch 3/8 inch.
4. Maximum Offset: 1/8 inch.
5. Joint: Flanged.
6. Size: Use pipe sized units.
7. Accessories: Internal flow liner.
8. Application: Steel piping 3 inch and larger.

2.3 FLEXIBLE EXPANSION LOOPS

A. Manufacturers:

1. Flexicraft.

2. Flex Hose.

3. Metraflex.

B. Flexible Expansion Loops shall consist of two parallel sections of corrugated metal hose, braid and a 180 degree return bend, or three equal length sections of annular corrugated close-pitch hose with over-braid, with inlet and outlet 90 degree elbow connections.

C. Type 304 Stainless steel braids shall be used with type 321 stainless steel hose. Fitting materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings.

D. The loops shall be engineered to move in all three planes, and shall impart no thrust loads to system anchors.

E. Field fabricated loops shall not be acceptable.

2.4 ACCESSORIES

A. Pipe Alignment Guides: Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inch travel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.

B. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

C. Rigidly anchor pipe to building structure. Provide pipe guides to direct movement only along axis of pipe. Erect piping so strain and weight is not on cast connections or apparatus.

D. Provide support and anchors for controlling expansion and contraction of piping. Provide loops, pipe offsets, and expansion joints where required.

E. Provide grooved piping systems with manufacturer recommended coupling and installation for flexible connectors or flexible connector supported by vibration isolation.

3.2 PIPE BEND AND LOOP INSTALLATION

1. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
2. Attach pipe bends and loops to anchors:
   a. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualification.”
   b. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer’s written instructions.

3.3 MANUFACTURER'S FIELD SERVICES

A. Furnish inspection services by flexible pipe manufacturer's representative for final installation and certify installation is in accordance with manufacturer's recommendations and connectors are performing satisfactorily.

END OF SECTION 23 05 16

SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gate valves.
2. Globe valves.
3. Ball valves.
4. Plug valves.
5. Butterfly valves.
6. Check valves
7. Pressure and Safety relieve valves.

1.2 REFERENCES

A. ASTM International:

1. ASTM A216 / A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
2. ASTM D1785 - Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.

B. ASTM D4101 - Standard Specification for Propylene Injection and Extrusion Materials.

1.3 SUBMITTALS

A. Product Data: Submit manufacturers catalog information with valve data and ratings for each service.

PART 2 - PRODUCTS

2.1 GATE VALVES

A. Manufacturers:

1. Crane.

2. Milwaukee.

3. Nibco

B. 2 inches and Smaller: MSS SP 80, Class 125, bronze body, bronze trim, threaded bonnet, rising stem, inside screw solid wedge disc, solder or threaded ends.

C. 2-1/2 inches and Larger: MSS SP 70, Class 125, cast iron body, bronze trim, bolted bonnet, rising stem, hand-wheel, outside screw and yoke, solid wedge disc with bronze seat rings, flanged ends. Furnish chain-wheel operators for valves 6 inches and larger mounted over 8 feet above floor.

2.2 GLOBE VALVES

A. Manufacturers:

1. **Crane**
2. **Milwaukee**
3. **Nibco**

B. 2 inches and Smaller: MSS SP 80, Class 125, bronze body, bronze trim, threaded bonnet, hand wheel, Buna-N composition disc, solder or threaded ends.

C. 2-1/2 inches and Larger: MSS SP 85, Class 125, cast iron body, bronze trim, hand wheel, outside screw and yoke, flanged ends. Furnish chain-wheel operators for valves 6 inches and larger mounted over 8 feet above floor.

2.3 BALL VALVES

A. Manufacturers:

1. **Crane**
2. **Milwaukee**
3. **Nibco**

B. 2 inches and Smaller: MSS SP 110, Class 150, bronze, two piece body, type 316 stainless steel ball, full port, teflon seats, blow-out proof stem, solder or threaded end and handle with balancing stops.

2.4 PLUG VALVES

A. Manufacturers:

1. **Nordstrom**
2. **Dezurik**
3. **Crane**

B. 2 inches and Smaller: MSS SP 78, Class 300, cast iron construction, round port, full pipe area, pressure lubricated, teflon packing, threaded ends. Furnish one plug valve wrench for every ten plug-valves with minimum of one wrench.

C. 2-1/2 inches and Larger: MSS SP 78, Class 300, cast iron construction, round port, full pipe area, pressure lubricated, teflon packing, flanged ends. Furnish wrench-operated or worm gear-operated.

2.5 BUTTERFLY VALVES

A. Manufacturers:

1. Crane

2. Milwaukee

3. Nibco

B. 2-1/2 inches and Larger: MSS SP 67, Class 200.

1. Body: Cast or ductile iron, lug or grooved ends, stainless steel stem, extended neck.
2. Disc: Aluminum bronze.
3. Seat: Resilient replaceable EPDM.
4. Handle and Operator: Infinite position lever handle with memory stop. Furnish gear operators for valves 8 inches and larger, and chain-wheel operators for valves mounted over 8 feet above floor.

2.6 CHECK VALVES

A. Horizontal Swing Check Valves:

1. Manufacturers:

a. Crane

b. Milwaukee

c. Nibco

2. 2 inches and Smaller: MSS SP 80, Class 150, bronze body and cap, bronze seat, Buna-N, solder or threaded ends.
3. 2-1/2 inches and Larger: MSS SP 71, Class 125, cast iron body, bolted cap, bronze or cast iron disc, renewable disc seal and seat, flanged ends.

B. Spring Loaded Check Valves:

1. Manufacturers:

a. Crane.

b. Milwaukee

c. Nibco

2. 2 inches and Smaller: MSS SP 80, Class 250, bronze body, in-line spring lift check, silent closing, Buna-N disc, integral seat, solder or threaded ends.
3. 2-1/2 inches and Larger: MSS SP 71, Class 125, wafer style, cast iron body, bronze seat, center guided bronze disc, stainless steel spring and screws, flanged ends.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install valves with stems upright or horizontal, not inverted.

B. Install valves with clearance for installation of insulation and allowing access.

C. Provide access where valves and fittings are not accessible.

3.2 VALVE APPLICATIONS

A. Install shutoff and drain valves at locations in accordance with this Section.

B. Install butterfly or gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.

C. Install ball butterfly or globe valves for throttling, bypass, or manual flow control services.

D. Install spring loaded check valves on discharge of water pumps.

E. Install lug end butterfly valves adjacent to equipment when functioning to isolate equipment.

F. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly gate, or plug valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Throttling and By-Pass Service: Globe, ball, or butterfly valves.
   4. Pump-Discharge Check Valves: Center-guided silent check valves.
   5. Lubricated plug valves may be used for throttling service. Non-lubricated plug valves may be used only when shut-off or isolating valves are also provided.
   6. Install drain valves, with cap and chain, as noted.
      a. All applications use 3/4 inch ball or globe valves.
   7. Provide 1/4 inch ball valve as gauge cocks.

G. Safety and Relief Valves:
   1. Constructed, rated and stamped in accordance with ASME
      a. Install relief valves for unheated liquids.
      b. Install safety relief valves for heated liquids.
      c. Install safety valves for steam.
   2. Set Pressures and Ratings:
      a. Suitable and rated for system pressure and temperature.

1) For Safety Relief Valves: Minimum temperature rating shall be equal to saturated steam temperature corresponding to pressure 10 percent higher than valve set pressure.

b. Set pressure; not to exceed pressure rating of protected equipment.

3. Valves to open, under test, at set pressure with following tolerance:
   a. Set pressure up to 70 psi: Plus or minus 2 psi.
   b. Set pressure, above 70 psi: Plus or minus 3 percent.
4. Capacities: Selected and sized to:
   a. Relieve maximum possible generated energy.
   b. Maintain pressure in protected equipment at not more than following:
      1) Low Pressure Boilers: 5 psi above boiler working pressure.
      2) Unfired Pressure Vessels: 10 percent above vessel working pressure.
5. Provide multiple valves if required to meet capacity requirements.

H. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

I. Select valves, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.
   7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.3 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: Two piece, full port, brass with brass trim.
   3. Bronze Swing Check Valves: Class 125, bronze disc.
   4. Bronze Gate Valves: Class 125, RS, bronze.
   5. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. Iron Swing Check Valves: Class 125, metal seats.
6. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
7. Iron, Center-Guided Check Valves: Class 125, globe, metal seat.
8. Iron Gate Valves: Class 125, OS&Y.
9. Iron Globe Valves: Class 125.
10. Lubricated Plug Valves: Class 125, regular gland, flanged.

3.4 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, brass with brass trim.
3. Bronze Swing Check Valves: Class 125, bronze disc.
4. Bronze Gate Valves: Class 125, RS.
5. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. Iron Swing Check Valves: Class 125, metal seats.
6. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
7. Iron, Center-Guided Check Valves: Class 125, globe, metal seat.
8. Iron Gate Valves: Class 125, OS&Y.
9. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 125.

END OF SECTION 23 05 23

SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Hanger rods.
3. Inserts.
4. Flashing.
5. Equipment curbs.
6. Sleeves.
7. Mechanical sleeve seals.
8. Formed steel channel.
9. Firestopping relating to HVAC work.
10. Firestopping accessories.
11. Equipment bases and supports.

1.2 SUBMITTALS

A. Shop Drawings: Indicate system layout with location including critical dimensions, sizes, and pipe hanger and support locations and detail of trapeze hangers.

B. Product Data:

1. Hangers and Supports: Submit manufacturers catalog data including load capacity.
2. Firestopping: Submit data on product characteristics, performance and limitation criteria.

C. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.

D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers. Submit sizing methods calculations sealed by a registered professional engineer.

E. Manufacturer's Installation Instructions:

1. Hangers and Supports: Submit special procedures and assembly of components.
2. Firestopping: Submit preparation and installation instructions.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

G. Engineering Judgments: For conditions not covered by UL or WH listed designs, submit judgments by licensed professional engineer suitable for presentation to authority having jurisdiction for acceptance as meeting code fire protection requirements.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Manufacturers:
   1. **Tolco/ B-Line Systems/ Cooper Industries.**
   2. **PHD Manufacturing.**
   3. **Or Approved Equal.**

B. Hydronic Piping:
   1. Conform to ASME B31.9 and ASME B31.1.
   2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Carbon steel, adjustable swivel, split ring.
   3. Hangers for Cold Pipe Sizes 2 inches and Larger: Carbon steel, adjustable, clevis.
   4. Hangers for Hot Pipe Sizes 2 to 4 inches: Carbon steel, adjustable, clevis.
   5. Hangers for Hot Pipe Sizes 6 inches and Larger: Adjustable steel yoke, cast iron roll, double hanger.
   6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches and Larger: Steel channels with welded spacers and hanger rods, cast iron roll.
   8. Wall Support for Pipe Sizes 3 inches and Smaller: Cast iron hooks.
   9. Wall Support for Pipe Sizes 4 inches and Larger: Welded steel bracket and wrought steel clamp.
   10. Wall Support for Hot Pipe Sizes 6 inches and Larger: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
   11. Vertical Support: Steel riser clamp.
   12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   13. Floor Support for Hot Pipe Sizes 4 Inches and Smaller: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   14. Floor Support for Hot Pipe Sizes 6 inches and Larger: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
   15. Copper Pipe Support: Copper-plated, carbon steel ring.

C. Refrigerant Piping:
   1. Conform to ASME B31.5.
   2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Carbon steel, adjustable swivel, split ring.
   3. Hangers for Pipe Sizes 2 inches and Larger: Carbon steel, adjustable, clevis.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Wall Support for Pipe Sizes 3 inches and Smaller: Cast iron hook.
   6. Wall Support for Pipe Sizes 4 inches and Larger: Welded steel bracket and wrought steel clamp.
   7. Vertical Support: Steel riser clamp.
   8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

9. Copper Pipe Support: Copper-plated carbon-steel ring.

2.2 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

2.3 INSERTS

A. Manufacturers:
   1. **Tolco/ B-Line Systems/ Cooper Industries.**
   2. **PHD Manufacturing.**
   3. **Or Approved Equal.**

B. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods; casting anchors or anchor inserts are acceptable.

2.4 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support exterior piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
   1. Manufacturers:
      a. **ERICO/Michigan Hanger Co.**
      b. **MIRO Industries**.
      c. **Or Approved Equal**.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
   1. Manufacturers:
      a. **MIRO Industries.**
      b. **Or Approved Equal.**

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   1. Manufacturers:
      a. **ERICO/Michigan Hanger Co.**
      b. **MIRO Industries.**
      c. **Portable Pipe Hangers, L.P.** (Houston, Texas).
   2. Base: Stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.

4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:
   a. **Portable Pipe Hangers, L.P.** (Houston, Texas).
   b. **Or Approved Equal**.
2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.5 FLASHING

A. Metal Flashing: 26 gauge galvanized steel.

B. Metal Counter-flashing: 22 gauge galvanized steel.

C. Lead Flashing:
1. Waterproofing: 5 lb./sq. ft sheet lead.
2. Soundproofing: 1 lb./sq. ft sheet lead.

D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.

2.6 EQUIPMENT CURBS

A. Manufacturers: To match equipment.

2.7 SLEEVES

A. Sleeves for Pipes through Non-fire Rated Floors: 18 gauge galvanized steel.

B. Sleeves for Pipes through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gauge galvanized steel.

C. Sleeves for Round Ductwork: Galvanized steel.

D. Sleeves for Rectangular Ductwork: Galvanized steel.

2.8 MECHANICAL SLEEVE SEALS

A. Manufacturers:
   1. **Thunderline Link-Seal, Inc.**
   2. **NMP Corporation.**
   3. **Or Approved Equal.**

B. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.9 FORMED STEEL CHANNEL

A. Manufacturers:
   1. **Tolco/B-Line Systems/ Cooper Industries.**
   2. **Hilti.**
   3. **Unistrut Corp.**

B. Product Description: Galvanized 12 gauge steel, with holes 1-1/2 inches on center.

2.10 FIRESTOPPING

A. Manufacturers:
   1. **Dow Corning Corp.**
   2. **Hilti Corp.**
   3. **3M Fire Protection Products**.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify openings are ready to receive sleeves.

B. Verify openings are ready to receive firestopping.

3.2 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

B. Remove incompatible materials affecting bond.

C. Install materials to arrest liquid material leakage.

D. Obtain permission from LAWA before using Powder-Actuated Fasteners.

E. Obtain permission from LAWA before drilling or cutting structural members.

3.3 INSTALLATION - INSERTS

A. Install inserts for placement in concrete forms.

B. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.4 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install hangers with minimum 1/2 inch space between finished covering and adjacent work.

B. Place hangers within 12 inches of each horizontal elbow, 12 inches from end of fitting.

C. Use hangers with 1-1/2 inch minimum vertical adjustment.

D. Support vertical piping at every other floor.

E. Where piping is installed in parallel and at same elevation, provide multiple pipe or trapeze hangers.

F. Support riser piping independently of connected horizontal piping.

G. Design hangers for pipe movement without disengagement of supported pipe.

H. Prime coat exposed steel hangers and supports.

I. Provide clearance in hangers and from structure and other equipment for installation of insulation.

3.5 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 3-1/2 inches thick and extending 6 inches beyond supported equipment.

B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct supports of steel members formed steel channel steel pipe and fittings. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.6 INSTALLATION - FLASHING

A. Provide flexible flashing and metal Counter-flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms for sound control.

C. Provide curbs for roof installations 14 inches minimum high above roofing surface. Flash and counter-flash with sheet metal; seal watertight. Attach Counter-flashing to equipment and lap base flashing on roof curbs. Flatten and solder joints.

D. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.7 INSTALLATION - SLEEVES

A. Exterior watertight entries: Seal with mechanical sleeve seals.

B. Set sleeves in position in forms. Provide reinforcing around sleeves.

C. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

D. Extend sleeves through floors one inch above finished floor level. Caulk or seal sleeves.

E. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with firestopping insulation and caulk. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

F. Install escutcheons at finished surfaces to match surface, or chrome.

3.8 INSTALLATION - FIRESTOPPING

A. Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping, ductwork, and other items, requiring firestopping.

B. Apply primer where recommended by manufacturer for type of firestopping material and substrate involved, and as required for compliance with required fire ratings.

C. Apply firestopping material in sufficient thickness to achieve required fire and smoke rating.

D. Fire Rated Surface:

1. Seal openings

E. Field Identification of Firestop Systems: Provide an identification tag at the location of each firestop system with a permanent label or mobile application QR tag, marking to indicate the name of the installer, the date of installation, the name of manufacturer and firestop system,

the name of testing agency and tested firestop system identification, and the words "Do Not Disturb – Fire Resistance Rated System."

F. Install firestopping product in accordance with manufacturer's instructions.

END OF SECTION 23 05 29

GUIDE SPECIFICATION
Los Angeles World Airports

SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vibration isolators.
2. Duct silencers.
3. Ductwork lagging.

1.2 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA).

B. American National Standards Institute (ANSI):

1. ANSI S1.4 - Sound Level Meters.
2. ANSI S1.8 - Reference Quantities for Acoustical Levels.
3. ANSI S1.13 - Methods for the Measurement of Sound Pressure Levels in Air.
4. ANSI S12.36 - Survey Methods for the Determination of Sound Power Levels of Noise Sources.

C. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):

1. ANSI/AHRI 575 - Method of Measuring Machinery Sound Within An Equipment Space.

D. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
2. ASHRAE Handbook - HVAC Applications.

E. ASTM International:

1. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
2. ASTM E477 - Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
3. ASTM E596 - Standard Test Method for Laboratory Measurement of Noise Reduction of Sound-Isolating Enclosures.

F. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

1. ANSI/SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

G. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):

1. MSS SP-127 – Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application.

1.3 SUBMITTALS

A. Shop Drawings: Indicate equipment bases and locate vibration isolators, with static and dynamic load on each. Indicate assembly, material, thickness, dimensional data, pressure losses, acoustical performance, layout, and connection details for sound attenuation products fabricated for this project.

B. Product Data: Submit schedule of vibration isolator type with location and load on each. Submit catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance for standard sound attenuation products.

1.4 PERFORMANCE

A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval from LADBS or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings.

B. All anchor bolts and tie-ins to structure shall be designed per the Airport Structural Design Standards.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers:

1. ISAT.

2. Mason Industries.

3. **Or approved equal.**

B. Open Spring Isolators:

1. Spring Isolators:
   a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
   b. Code: Color code springs for load carrying capacity.
2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
3. Spring Mounts: Furnish with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
4. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.

C. Restrained Spring Isolators:

1. Spring Isolators:
    a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
    b. Code: Color code springs for load carrying capacity.
2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
3. Spring Mounts: Furnish with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
4. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
5. Restraint: Furnish mounting frame and limit stops.

D. Closed Spring Isolators:
1. Spring Isolators:
    a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
    b. Code: Color code springs for load carrying capacity.
2. Type: Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
3. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
4. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 0.25 inch clearance.

E. Restrained Closed Spring Isolators:
1. Spring Isolators:
    a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
    b. Code: Color code springs for load carrying capacity.
2. Type: Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.
3. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
4. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators, and neoprene side stabilizers with minimum 0.25 inch clearance and limit stops.

F. Spring Hanger:
1. Spring Isolators:
    a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
    b. Code: Color code springs for load carrying capacity.

2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
3. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators rubber hanger with threaded insert.
4. Misalignment: Capable of 20 degree hanger rod misalignment.

G. Neoprene Pad Isolators:

1. Rubber or neoprene-waffle pads.
   a. 30 durometer.
   b. Minimum 0.5 inch thick.
   c. Maximum loading 40 psi.
   d. Height of ribs: not to exceed 0.7 times width.
2. Configuration: Single layer. 0.5 inch thick waffle pads bonded each side of 1/4 inch thick steel plate.

H. Rubber Mount or Hanger: Molded rubber designed for 0.5 inches deflection with threaded insert.

I. Glass Fiber Pads: Neoprene jacketed pre-compressed molded glass fiber.

J. Seismic Snubbers:

1. Type: Non-directional and double acting unit consisting of interlocking steel members restrained by neoprene elements.
2. Neoprene Elements: Replaceable, minimum of 0.75 inch thick.
3. Capacity: 4 times load assigned to mount groupings at 0.4 inch deflection.
4. Attachment Points and Fasteners: Capable of withstanding 3 times rated load capacity of seismic snubber.

2.2 DUCT SILENCERS

A. Manufacturers:

1. Noise Control, Inc.

2. McGill Airflow LLC.

3. Semco.

B. Description: Duct section with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction.

2.3 DUCTWORK LAGGING

A. Acoustic Insulation: 2 inch thick, 3 to 5 lb/cu ft density glass fiber or mineral wool insulation.

B. Covering: Sheet lead, vinyl, or gypsum board with surface weight minimum 4 lb/sq ft.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify equipment, ductwork and piping is installed before work in this section is started.

3.2 EXISTING WORK

A. Provide access to existing piping and ductwork and other installations remaining active and requiring access.

B. Extend existing piping and ductwork installations using materials and methods compatible with existing electrical installations.

3.3 INSTALLATION

A. Support duct silencers independent of ductwork.

B. Lag ductwork by wrapping with insulation and covering. Apply covering to be airtight. Do not attach covering rigidly to ductwork.

C. Install isolation for motor driven equipment.

D. Adjust equipment level.

E. Install spring hangers without binding.

F. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

3.4 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
4. All equipment whether isolated or not, shall be bolted to structure to allow for minimum 0.5g of acceleration.
5. All structurally suspended overhead equipment isolated or non-isolated shall be four point independently braced within Type III seismic restraining system.
6. Where base anchoring is insufficient to resist seismic forces, supplementary restraining such as seismic restraint system Type III shall be used above systems center of gravity to

suitably resist "G" force levels. Vertically mounted tanks may require this additional restraint.

B. Piping Restraints:

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.
3. Install Seismic Restraining System Type III: Taut for overhead suspended non-isolated equipment, piping and slack with 0.5 inch cable deflection for isolated systems.
4. Seismically restrain all piping with Type III restraining system in accordance with guideline as outlined below.
5. Install vibration isolation at all piping connected to rotating equipment and within 50 feet of each piece of equipment such as air handling units, fan coil units and computer room AC units, condensing units, exhaust fans and make-up air units.

C. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify LAWA if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Screw Anchors: Clean holes to remove loose material and drilling dust prior to installation of anchor.
6. Set anchors to manufacturer's recommended torque, using a torque wrench.
7. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.
8. Provide LA Research Reports (LARR numbers) or product approval by another agency acceptable to authorities having jurisdiction for all applicable products and anchorages.

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Nameplates.
   2. Tags.
   3. Stencils.
   4. Pipe markers.
   5. Ceiling tacks.
   6. Labels.
   7. Lockout devices.
   8. Warning Signs & Labels.

1.2 REFERENCES

A. American Society of Mechanical Engineers:
   1. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.3 SUBMITTALS

A. Product Data: Submit manufacturers catalog literature for each product required.

B. Samples.

C. Shop Drawings: Submit list of wording, symbols, letter size, and color coding for mechanical identification and valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Manufacturers:
   1. **Craftmark Pipe Markers.**
   2. **Seton Identification Products / Tricor Direct / Brady Corporation.**
   3. **Kolbi Pipe Marker Company.**

B. Product Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

C. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2 TAGS

A. Plastic Tags:

1. Manufacturers:
   a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
   b. **Brady Worldwide, Inc.**
   c. **Kolbi Pipe Marker Company.**
2. Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inches diameter square.

B. Metal Tags:

1. Manufacturers:
   a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
   b. **Brady Worldwide, Inc.**
   c. **Kolbi Pipe Marker Company.**
2. Aluminum with stamped letters; tag size minimum 1-1/2 inches diameter with finished edges.

C. Tag Chart: Typewritten letter size list of applied tags and location in anodized aluminum frame plastic laminated.

2.3 STENCILS

A. Manufacturers:
   a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
   b. **Brady Worldwide, Inc.**
   c. **Kolbi Pipe Marker Company.**

B. Stencils: With clean cut symbols and letters of following size:

1. Up to 2 inches Outside Diameter of Insulation or Pipe: 1/2 inch high letters.
2. 2-1/2 to 6 inches Outside Diameter of Insulation or Pipe: 1-inch high letters.

3. Over 6 inches Outside Diameter of Insulation or Pipe: 1-3/4 inches high letters.
4. Ductwork and Equipment: 1-3/4 inches high letters.

C. Stencil Paint: Semi-gloss enamel.

2.4 PIPE MARKERS

A. Plastic Pipe Markers:
1. Manufacturers:
a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
b. **Brady Worldwide, Inc.**
c. **Kolbi Pipe Marker Company.**
2. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.

B. Plastic Tape Pipe Markers:
1. Manufacturers:
a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
b. **Brady Worldwide, Inc.**
c. **Kolbi Pipe Marker Company.**
2. Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

2.5 CEILING TACKS

A. Manufacturers:
1. **Seton Identification Products / Tricor Direct / Brady Corporation.**
2. **Brady Worldwide, Inc.**
3. **Kolbi Pipe Marker Company.**

B. Description: Steel with 3/4 inch diameter color-coded head.

C. Color code as follows:
1. HVAC equipment: Yellow.
2. Fire dampers/smoke dampers: Red.
3. Plumbing valves: Green.
4. Heating/cooling valves: Blue.

2.6 LABELS

A. Manufacturers:
1. **Seton Identification Products / Tricor Direct / Brady Corporation.**
2. **Brady Worldwide, Inc.**
3. **Kolbi Pipe Marker Company.**

B. Description: Aluminum, size 1.9 x 0.75 inches, adhesive backed with printed identification.

C. Pipe Labels:

1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
    a. NPS 5 (DN 125) and smaller: Attach to pipe without fasteners or adhesive.
    b. NPS 6 (DN 150) and larger: Attach to pipe with stainless steel spring fasteners.
3. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
    a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
    b. Lettering Size: At least 1-1/2 inches high.
4. Maximum Temperature: Able to withstand temperatures up to 180 deg F (83 deg C).

D. Duct Labels:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: Blue.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
9. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
    a. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.
    b. Lettering Size: At least 1-1/2 inches high.

2.7 LOCKOUT DEVICES

A. Lockout Hasps:

1. Manufacturers:

a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
b. **Brady Worldwide, Inc.**
c. **Kolbi Pipe Marker Company.**

2. Anodized aluminum hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

B. Valve Lockout Devices:

1. Manufacturers:
   a. **Seton Identification Products / Tricor Direct / Brady Corporation.**
   b. **Brady Worldwide, Inc.**
   c. **Kolbi Pipe Marker Company.**
2. Steel device preventing access to valve operator, accepting lock shackle.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces for stencil painting.

3.2 INSTALLATION

A. Apply stencil painting.

B. Install identifying devices after completion of coverings and painting.

C. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

D. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.

E. Install tags using corrosion resistant chain. Number tags consecutively by location.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing, adjusting, and balancing of air systems.
2. Testing, adjusting, and balancing of hydronic systems.
3. Measurement of final operating condition of HVAC systems.
4. Sound measurement of equipment operating conditions.
5. Vibration measurement of equipment operating conditions.
6. Testing, adjusting and balancing of smoke control systems.

1.2 REFERENCES

A. Associated Air Balance Council (AABC):

1. AABC MN-1 - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

B. National Environmental Balancing Bureau (NEBB):

1. Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems. Latest Edition.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.
2. ASHRAE 62.1, Section 7.2.2.
3. ASHRAE 90.1, Section 6.2.3 System Balancing.

1.3 SUBMITTALS

A. Prior to commencing Work, submit proof of latest calibration date of each instrument.

B. Test Reports: Indicate data on AABC or NEBB Total System Balance forms.

C. Field Reports: Indicate deficiencies preventing proper testing, adjusting, and balancing of systems and equipment.

D. Prior to commencing Work, submit report forms or outlines indicating adjusting, balancing, and equipment data required. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty.

E. Submit draft copies of report for review prior to final acceptance of Project.

F. Furnish printed reports (not hand-written) in binder manuals, complete with table of contents page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Furnish final copy of testing, adjusting, and balancing report inclusion in operating and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Prior to commencing Work, calibrate each instrument to be used. Upon completing Work, recalibrate each instrument to assure reliability.

1.6 QUALIFICATIONS

A. Agency: Company specializing in testing, adjusting, and balancing of systems specified in this section with minimum five years documented experience certified by AABC or NEBB.

1.7 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee AABC or NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.
3. Warranty Period: Five (5) years.

B. Special Guarantee: Provide a guarantee AABC or NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.
3. Warranty Period: Five (5) years.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify systems are complete and operable before commencing work. Verify the following:

1. Systems are started and operating in safe and normal condition.
2. Temperature control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
5. Duct systems are clean of debris.
6. Fans are rotating correctly.
7. Fire and volume dampers are in place and open.
8. Air coil fins are cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and connected.
11. Duct system leakage is minimized.
12. Hydronic systems are flushed, filled, and vented.
13. Pumps are rotating correctly.
14. Proper strainer baskets are clean and in place or in normal position.
15. Service and balancing valves are open.
16. Drains are flushed and clean.

3.2 PREPARATION

A. Furnish instruments required for testing, adjusting, and balancing operations.

B. Make instruments available to LAWA to facilitate spot checks during testing.

3.3 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 10 percent of design.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.4 ADJUSTING

A. Verify recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted. If disrupted, verify correcting adjustments have been made.

D. Report defects and deficiencies noted during performance of services, preventing system balance.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

F. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by LAWA.

G. Check and adjust systems approximately six months after final acceptance and submit report.

3.5 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to obtain required or design supply, return, and exhaust air quantities.

B. Make air quantity measurements in main ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts.

E. Use volume control devices to regulate air quantities only to extent adjustments do not create objectionable air motion or sound levels. Effect volume control by using volume dampers located in ducts.

F. Vary total system air quantities by adjustment of fan speeds. Provide sheave drive changes if applicable to vary fan speed. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. At modulating damper locations, take measurements and balance at extreme conditions. Balance variable volume systems at maximum airflow rate, full cooling, and at minimum airflow rate, full heating.

L. Measure building static pressure and adjust supply, return, and exhaust air systems to obtain required relationship between each to maintain approximately 0.05 inches positive static pressure near building entries.

M. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

N. For variable air volume system powered units set volume controller to airflow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable-air-volume temperature control.

O. On fan powered VAV boxes, adjust airflow switches for proper operation.

3.6 WATER SYSTEM PROCEDURE

A. Adjust water systems, after air balancing, to obtain design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow-metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in system.

C. Adjust systems to obtain prescribed pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open or in normal position to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, simulate full flow in one part by temporary restriction of flow to other parts.

3.7 PROCEDURES FOR SMOKE-CONTROL SYSTEM TESTING

A. Before testing smoke-control systems, verify that construction is complete and verify the integrity of each smoke-control zone boundary. Verify that windows and doors are closed and that applicable safing, gasket, and sealants are installed.

B. Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

C. Measure, adjust, and record airflow of each smoke-control system with all fans that are a part of the system.

D. Measure, adjust, and record the airflow of each fan. For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

E. After air balancing is complete, perform the pressurization testing for each smoke-control zone.

F. Operational Tests:

1. Check the proper activation of each zoned smoke-control system in response to all means of activation, both automatic and manual.
2. Check automatic activation in response to fire alarm signals received from the building's fire alarm and detection system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zoned smoke-control system occurs.
3. Check and record the proper operation of fans, dampers, and related equipment for each separate zone of the smoke-control system.

G. Conduct additional tests required by authorities having jurisdiction. Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.

H. Prepare a complete report of observations, measurements, and deficiencies.

3.8 SCHEDULES

A. Equipment Requiring Testing, Adjusting, and Balancing:

1. Pumps.
2. Air Cooled Refrigerant Condensers/Condensing Units.
3. Packaged Roof Top Heating/Cooling Units.
4. Packaged Terminal Air Conditioning Units.
5. Unit Air Conditioners.
6. Computer Room Air Conditioning Units.
7. Air Coils.
8. Evaporative Humidifier.
9. Fan Coil Units.
10. Air Handling Units.
11. Fans.
12. Air Filters.
13. Air Terminal Units.
14. Air Inlets and Outlets.
15. Heat Exchangers.

B. Report Forms

1. Title Page:
    a. Name of Testing, Adjusting, and Balancing Agency
    b. Address of Testing, Adjusting, and Balancing Agency
    c. Telephone and facsimile numbers of Testing, Adjusting, and Balancing Agency
    d. Project name
    e. Project location
    f. Project Architect
    g. Project Engineer
    h. Project Contractor
    i. Project altitude
    j. Report date
2. Summary Comments:
    a. Design versus final performance
    b. Notable characteristics of system
    c. Description of systems operation sequence
    d. Summary of outdoor and exhaust flows to indicate building pressurization
    e. Nomenclature used throughout report
    f. Test conditions
3. Instrument List:
    a. Instrument
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Range
    f. Calibration date
4. Electric Motors:
    a. Manufacturer
    b. Model/Frame
    c. HP/BHP and kW
    d. Phase, voltage, amperage; nameplate, actual, no load
    e. RPM
    f. Service factor
    g. Starter size, rating, heater elements
    h. Sheave Make/Size/Bore
5. V-Belt Drive:
    a. Identification/location
    b. Required driven RPM
    c. Driven sheave, diameter and RPM

d. Belt, size and quantity
e. Motor sheave diameter and RPM
f. Center to center distance, maximum, minimum, and actual

6. Pump Data:
   a. Identification/number
   b. Manufacturer
   c. Size/model
   d. Impeller
   e. Service
   f. Design flow rate, pressure drop, BHP and kW
   g. Actual flow rate, pressure drop, BHP and kW
   h. Discharge pressure
   i. Suction pressure
   j. Total operating head pressure
   k. Shut off, discharge and suction pressures
   l. Shut off, total head pressure

7. Air Cooled Condenser/Condensing Unit:
   a. Identification/number
   b. Location
   c. Manufacturer
   d. Model number
   e. Serial number
   f. Entering DB air temperature, design and actual
   g. Leaving DB air temperature, design and actual
   h. Number of compressors

8. Heat Exchanger:
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Model number
   f. Serial number
   g. Steam pressure, design and actual
   h. Primary water entering temperature, design and actual
   i. Primary water leaving temperature, design and actual
   j. Primary water flow, design and actual
   k. Primary water pressure drop, design and actual
   l. Secondary water leaving temperature, design and actual
   m. Secondary water leaving temperature, design and actual
   n. Secondary water flow, design and actual

o. Secondary water pressure drop, design and actual

9. Cooling Coil Data:
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Air flow, design and actual
   f. Entering air DB temperature, design and actual
   g. Entering air WB temperature, design and actual
   h. Leaving air DB temperature, design and actual
   i. Leaving air WB temperature, design and actual
   j. Water flow, design and actual
   k. Water pressure drop, design and actual
   l. Entering water temperature, design and actual
   m. Leaving water temperature, design and actual
   n. Saturated suction temperature, design and actual
   o. Air pressure drop, design and actual
10. Heating Coil Data:
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Air flow, design and actual
   f. Water flow, design and actual
   g. Water pressure drop, design and actual
   h. Entering water temperature, design and actual
   i. Leaving water temperature, design and actual
   j. Entering air temperature, design and actual
   k. Leaving air temperature, design and actual
   l. Air pressure drop, design and actual
11. Unit Ventilator and Fan Coil Data:
   a. Manufacturer
   b. Identification/number
   c. Location
   d. Model number
   e. Size
   f. Air flow, design and actual
   g. Water flow, design and actual
   h. Water pressure drop, design and actual
   i. Entering water temperature, design and actual

j. Leaving water temperature, design and actual
k. Entering air temperature, design and actual
l. Leaving air temperature, design and actual

12. Air Moving Equipment:
    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Arrangement/Class/Discharge
    f. Air flow, specified and actual
    g. Return air flow, specified and actual
    h. Outside air flow, specified and actual
    i. Total static pressure (total external), specified and actual
    j. Inlet pressure
    k. Discharge pressure
    l. Sheave Make/Size/Bore
    m. Number of Belts/Make/Size
    n. Fan RPM

13. Return Air/Outside Air Data:
    a. Identification/location
    b. Design air flow
    c. Actual air flow
    d. Design return air flow
    e. Actual return air flow
    f. Design outside air flow
    g. Actual outside air flow
    h. Return air temperature
    i. Outside air temperature
    j. Required mixed air temperature
    k. Actual mixed air temperature
    l. Design outside/return air ratio
    m. Actual outside/return air ratio

14. Exhaust Fan Data:
    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Air flow, specified and actual
    f. Total static pressure (total external), specified and actual
    g. Inlet pressure

h. Discharge pressure
i. Sheave Make/Size/Bore
j. Number of Belts/Make/Size
k. Fan RPM

15. Duct Traverse:
    a. System zone/branch
    b. Duct size
    c. Area
    d. Design velocity
    e. Design air flow
    f. Test velocity
    g. Test air flow
    h. Duct static pressure
    i. Air temperature
    j. Air correction factor

16. Duct Leak Test:
    a. Description of ductwork under test
    b. Duct design operating pressure
    c. Duct design test static pressure
    d. Duct capacity, air flow
    e. Maximum allowable leakage duct capacity times leak factor
    f. Test apparatus
        1) Blower
        2) Orifice, tube size
        3) Orifice size
        4) Calibrated
    g. Test static pressure
    h. Test orifice differential pressure
    i. Leakage

17. Air Monitoring Station Data:
    a. Identification/location
    b. System
    c. Size
    d. Area
    e. Design velocity
    f. Design air flow
    g. Test velocity
    h. Test air flow

18. Flow Measuring Station:

a. Identification/number
b. Location
c. Size
d. Manufacturer
e. Model number
f. Serial number
g. Design Flow rate
h. Design pressure drop
i. Actual/final pressure drop
j. Actual/final flow rate
k. Station calibrated setting

19. Terminal Unit Data:
    a. Manufacturer
    b. Type, constant, variable, single, dual duct
    c. Identification/number
    d. Location
    e. Model number
    f. Size
    g. Minimum static pressure
    h. Minimum design air flow
    i. Maximum design air flow
    j. Maximum actual air flow
    k. Inlet static pressure

20. Air Distribution Test Sheet:
    a. Air terminal number
    b. Room number/location
    c. Terminal type
    d. Terminal size
    e. Area factor
    f. Design velocity
    g. Design air flow
    h. Test (final) velocity
    i. Test (final) air flow
    j. Percent of design air flow

21. Sound Level Report:
    a. Location
    b. Octave bands - equipment off
    c. Octave bands - equipment on
    d. RC level - equipment on

22. Vibration Test:
    a. Location of points:
        1) Fan bearing, drive end
        2) Fan bearing, opposite end
        3) Motor bearing, center (when applicable)
        4) Motor bearing, drive end
        5) Motor bearing, opposite end
        6) Casing (bottom or top)
        7) Casing (side)
        8) Duct after flexible connection (discharge)
        9) Duct after flexible connection (suction)
    b. Test readings:
        1) Horizontal, velocity and displacement
        2) Vertical, velocity and displacement
        3) Axial, velocity and displacement
    c. Normally acceptable readings, velocity and acceleration
    d. Unusual conditions at time of test
    e. Vibration source (when non-complying)

END OF SECTION 23 05 93

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC piping insulation, jackets and accessories.
2. HVAC ductwork insulation, jackets, and accessories.
3. Equipment Insulation, jackets and accessories.

1.2 REFERENCES

A. ASTM International and Underwriters Laboratories:

1. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
2. ASTM C450 - Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging.
3. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
4. ASTM D4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.
5. ASTM C165 – Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
6. ASTM C177 – Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
7. ASTM C335 – Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
8. ASTM C356 – Standard Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat.
9. ASTM C411 – Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
10. ASTM C447 – Standard Practice for Estimating the Maximum Use Temperature of Thermal Insulations.
11. ASTM C518 – Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
12. ASTM C1139 – Standard Specification for Fibrous Glass Thermal Insulation and Sound Absorbing Blanket and Board for Military Applications
13. ASTM C1393 – Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.

14. ASTM D624 – Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
15. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
16. ASTM E1196 – Standard Guide for Thermal Industrial Insulation Systems.
17. UL 723 – Test for Surface Burning Characteristics of Building Materials.
18. UL/ULC Classified – Underwriters Laboratories classification mark for products the UL has evaluated by its standards and are covered by UL's follow-up Services program.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.3 SUBMITTALS

A. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

1.4 WARRANTY

A. Furnish five year manufacturer warranty for man-made fiber.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturers for Glass Fiber and Mineral Fiber Insulation Products:
   1. Johns Manville.
   2. Knauf Insulation
   3. Owens-Corning.

B. Manufacturers for Closed Cell Elastomeric Insulation Products:
   1. Aeroflex. Aerocell.
   2. Armacell, LLC. Armaflex.
   3. Nomaco. K-flex.

2.2 PIPE INSULATION

A. TYPE P-1: ASTM C547, molded glass fiber pipe insulation. Conform to ASTM C795 for application on Austenitic stainless steel.
   1. Thermal Conductivity: 0.23 at 75 degrees F.

2. Operating Temperature Range: 0 to 850 degrees F.
3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F.

B. TYPE P-2: ASTM C547, molded glass fiber pipe insulation. Conform to ASTM C795 for application on Austenitic stainless steel.
1. Thermal Conductivity: 0.23 at 75 degrees F.
2. Operating Temperature Range: 0 to 850 degrees F.

C. TYPE P-3: ASTM C612; semi-rigid, fibrous glass board noncombustible, end grain adhered to jacket. Conform to ASTM C795 for application on Austenitic stainless steel.
1. Thermal Conductivity: 0.27 at 75 degrees F.
2. Operating Temperature Range: 0 to 650 degrees F.
3. Vapor Barrier Jacket: ASTM C1136, Type II, factory applied reinforced foil kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F.

D. TYPE P-4: ASTM C612; semi-rigid, fibrous glass board noncombustible. Conform to ASTM C795 for application on Austenitic stainless steel.
1. Thermal Conductivity: 0.27 at 75 degrees F.
2. Operating Temperature Range: 0 to 650 degrees F.

E. TYPE P-5: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.
1. Thermal Conductivity: 0.27 at 75 degrees F.
2. Operating Temperature Range: Minus 70 to 180 degrees F.

F. TYPE P-6: ASTM C534, Type I, Grade 2, flexible, closed cell elastomeric insulation, tubular.
1. Thermal Conductivity: 0.30 at 75 degrees F.
2. Maximum Service Temperature: 300 degrees F.
3. Operating Temperature Range: Minus 58 to 300 degrees F.

G. TYPE P-7: ASTM C534, Type I, flexible, non-halogen, closed cell elastomeric insulation, tubular.
1. Thermal Conductivity: 0.27 at 75 degrees F.
2. Maximum Service Temperature: 250 degrees F.
3. Operating Temperature Range: Minus 58 to 250 degrees F.

H. TYPE P-8: ASTM C547, Type I or II, mineral fiber preformed pipe insulation, noncombustible.

1. Thermal Conductivity: 0.23 at 75 degrees F.
2. Maximum Service Temperature: 1200 degrees F.
3. Canvas Jacket: UL listed, 6 oz/sq yd, plain weave cotton fabric treated with fire retardant lagging adhesive.

2.3 PIPE INSULATION JACKETS

A. Vapor Retarder Jacket:

1. ASTM C921, ASTM C1136 white Kraft paper with glass fiber yarn, bonded to aluminized film.
2. Water Vapor Permeance: ASTM E96 / E96M; 0.02 perms.

B. PVC Plastic Pipe Jacket:

1. Product Description: ASTM D1785, One piece molded type fitting covers and sheet material, off-white color.
2. Thickness: 30 mil.
3. Connections: Brush on welding adhesive with VOC content of 50 g/l according to 40 CFR 59, subpart D (EPA Method 24).

C. ABS Plastic Pipe Jacket:

1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
2. Water Vapor Permeance: ASTM E96 / E96M; 0.02 perms.
3. Thickness: 30 mil.
4. Connections: Brush on welding adhesive.

D. Aluminum Pipe Jacket:

1. ASTM B209.
2. Thickness: 0.2 inch thick sheet.
3. Finish: Embossed.
4. Joining: Longitudinal slip joints and 2 inch laps.
5. Fittings: 0.2 inch thick die shaped fitting covers with factory attached protective liner.

E. Stainless Steel Pipe Jacket:

1. ASTM A240 / A240M OR ASTM 666 Type 304 stainless steel.
2. Thickness: 0.016 inch thick.
3. Finish: Smooth.

F. Field Applied Glass Fiber Fabric Jacket System:

1. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2. Glass Fiber Fabric:
    a. Cloth: Untreated; 9 oz/sq yd weight.
    b. Blanket: 1.0 lb/cu ft density.

2.4 PIPE INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Piping 1-1/2 inches diameter and smaller: Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.

D. Piping 2 inches diameter and larger: Wood insulation saddle, hard maple. Inserts length: not less than 6 inches long, matching thickness and contour of adjoining insulation.

E. Closed Cell Elastomeric Insulation Pipe Hanger: Polyurethane insert with aluminum single piece construction with self-adhesive closure. Thickness to match pipe insulation.

F. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

G. Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement: ASTM C449 / C449M.

H. Insulating Cement: ASTM C195; hydraulic setting on mineral wool.

I. Adhesives: Compatible with insulation.

2.5 DUCTWORK INSULATION

A. TYPE D-1: ASTM C1290, Type III, flexible glass fiber, commercial grade with factory applied reinforced aluminum foil jacket meeting ASTM C1136, Type II.
    1. Thermal Conductivity: 0.27 at 75 degrees F.
    2. Maximum Operating Temperature: 250 degrees F.
    3. Density: 0.75 pound per cubic foot.

B. TYPE D-2: ASTM C612, Type IA or IB, rigid glass fiber, with factory applied all service facing meeting ASTM C1136, Type II.
    1. Thermal Conductivity: 0.22 at 75 degrees F.
    2. Density: 2.25 pound per cubic foot.

C. TYPE D-3: ASTM C612, Type IA or IB, rigid glass fiber, no facing.
    1. Thermal Conductivity: 0.24 at 75 degrees F.
    2. Density: 2.25 pound per cubic foot.

D. TYPE D-4: ASTM C1071, Type I, flexible, glass fiber duct liner with coated air side.
   1. Thermal Conductivity: 0.25 at 75 degrees F.
   2. Density: 1.5 pound per cubic foot.
   3. Maximum Operating Temperature: 250 degrees F.
   4. Maximum Air Velocity: 6,000 feet per minute.

E. TYPE D-5: ASTM C1071, Type II, rigid, glass fiber duct liner with coated air side.
   1. Thermal Conductivity: 0.23 at 75 degrees F.
   2. Density: 3.0 pound per cubic foot.
   3. Maximum Operating Temperature: 250 degrees F.
   4. Maximum Air Velocity: 4,000 feet per minute.

F. TYPE D-6: ASTM C534, Type II, flexible, closed cell elastomeric insulation, sheet.
   1. Thermal Conductivity: 0.27 at 75 degrees F.
   2. Service Temperature Range: Minus 58 to 180 degrees F.

2.6 DUCTWORK INSULATION JACKETS

A. Aluminum Duct Jacket:
   1. ASTM B209.
   2. Thickness: 0.016 inch thick sheet.
   3. Finish: Embossed.
   4. Joining: Longitudinal slip joints and 2 inch laps.
   5. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
   6. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

B. Vapor Retarder Jacket:
   1. Kraft paper with glass fiber yarn and bonded to aluminized film 0.0032 inch vinyl.
   2. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms.
   3. Secure with pressure sensitive tape.

C. Canvas Duct Jacket: UL listed, 6 oz/sq yd, plain weave cotton fabric with fire retardant lagging adhesive compatible with insulation.

D. Outdoor Duct Jacket: Asphalt impregnated and coated sheet, 36 lb/square.

2.7 DUCTWORK INSULATION ACCESSORIES

A. Vapor Retarder Tape:

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

B. Vapor Retarder Lap Adhesive: Compatible with insulation.

C. Adhesive: Waterproof, ASTM E162 fire-retardant type.

D. Liner Fasteners: Galvanized steel, self-adhesive pad with integral press-on head.

E. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

F. Lagging Adhesive: Fire retardant type with maximum 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

G. Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.

H. Adhesives: Compatible with insulation.

I. Membrane Adhesives: As recommended by membrane manufacturer.

2.8 EQUIPMENT INSULATION

A. TYPE E-1: ASTM C553; glass fiber, flexible or semi-rigid, noncombustible.

1. Thermal Conductivity: 0.24 at 75 degrees F .
2. Operating Temperature Range: 0 to 450 degrees F .
3. Density: 1.5 pound per cubic foot.

B. TYPE E-2: ASTM C612; glass fiber, rigid board, noncombustible with factory applied reinforced foil kraft jacket.

1. Thermal Conductivity: 0.24 at 75 degrees F .
2. Operating Temperature Range: 0 to 450 degrees F
3. Density: 3.0 pound per cubic foot.
4. Jacket Temperature Limit: minus 20 to 150 degrees F.

C. TYPE E-3: ASTM C612; semi-rigid, fibrous glass board noncombustible, end grain adhered to jacket.

1. Thermal Conductivity: 0.27 at 75 degrees F.
2. Operating Temperature Range: 0 to 650 degrees F .
3. Vapor Barrier Jacket: ASTM C1136, Type II, factory applied reinforced foil kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F.

D. TYPE E-4: ASTM C612; semi-rigid, fibrous glass board noncombustible.

1. Thermal Conductivity: 0.27 at 75 degrees F

2. Operating Temperature Range: 0 to 650 degrees F.

E. TYPE E-5: ASTM C552 Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Provide the following:

a. Cell-U-Foam Corporation; Ultra-CUF.

b. Pittsburgh Corning Corporation; Foamglas Super K.

2. Thermal Conductivity (k-value) at 75°F mean temperature is 0.27 Btu x in./hr. x ft. x degree F. or less.

3. Block Insulation: ASTM C552, Type I.

4. Special-Shaped Insulation: ASTM C552, Type III.

5. Board Insulation: ASTM C552, Type IV.

6. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.

7. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C552, Type II, Class 2.

8. Factory fabricate shapes according to ASTM C450 and ASTM C585.

F. TYPE E-7: ASTM C533; Type II, hydrous calcium silicate block insulation, asbestos free.

1. Thermal Conductivity: 0.45 at 200 degrees F

2. Operating Temperature Range: 140 to 1200 degrees F

G. TYPE E-9: ASTM C612, manmade mineral fiber, noncombustible, Classes 1-4.

1. Thermal Conductivity: 0.25 at 100 degrees F

2. Maximum Service Temperature: 1200 degrees F

3. Density: 4 pound per cubic foot.

2.9 EQUIPMENT INSULATION JACKETS

A. PVC Plastic Equipment Jacket:

1. Product Description: ASTM D1785, sheet material, off-white color.

2. Minimum Service Temperature: -40 degrees

3. Maximum Service Temperature: 150 degrees F

4. Water Vapor Permeance: ASTM E96 / E96M; 0.02 perms

5. Thickness: 10 mil.

6. Connections Pressure sensitive color matching vinyl tape.

B. Aluminum Equipment Jacket:

1. ASTM B209Thickness: 0.016 inch thick sheet.
2. Finish: Smooth
3. Joining: Longitudinal slip joints and 2 inch laps.
4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

C. Canvas Equipment Jacket: UL listed, 6 oz/sq yd, plain weave cotton fabric with fire retardant lagging adhesive compatible with insulation.

D. Vapor Retarder Jacket:

1. ASTM C921, ASTM C1136 white Kraft paper with glass fiber yarn, bonded to aluminized film.
2. Water Vapor Permeance: ASTM E96 / E96M; 0.02 perms.

E. Field Applied Glass Fiber Fabric Jacket System:

1. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
2. Glass Fiber Fabric:
   a. Cloth: Untreated; 9 oz/sq yd weight.
   b. Blanket: 1.0 lb/cu ft density.
   c. Weave: 5 x 5.
3. Indoor Vapor Retarder Finish:
   a. Cloth: Untreated; 9 oz/sq yd weight.
   b. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.10 EQUIPMENT INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

D. Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement: ASTM C449 / C449M.

E. Adhesives: Compatible with insulation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify piping, and ductwork has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION - PIPING SYSTEMS

A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations.

B. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Section 07 84 00 for penetrations of assemblies with fire resistance rating greater than one hour.

C. Piping Systems Conveying Fluids Below Ambient Temperature:

1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

D. Glass Fiber Board Insulation:

1. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.

E. Hot Piping Systems less than 140 degrees F:

1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
3. Do not insulate unions and flanges at equipment, but bevel and seal ends of insulation at such locations.

F. Hot Piping Systems greater than 140 degrees F:

1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied

jacket and butt strips or both.

2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
3. Insulate flanges and unions at equipment.

G. Inserts and Shields:

1. Piping 1-1/2 inches Diameter and Smaller: Install galvanized steel shield between pipe hanger and insulation.
2. Piping 2 inches Diameter and Larger: Install insert between support shield and piping and under finish jacket.
    a. Insert Configuration: Minimum 6 inches long, of thickness and contour matching adjoining insulation; may be factory fabricated.
    b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.
3. Piping Supported by Roller Type Pipe Hangers: Install galvanized steel shield between roller and inserts.

H. Insulation Terminating Points:

1. Coil Branch Piping 1 inch and Smaller: Terminate hot water piping at union upstream of the coil control valve.
2. Chilled Water Coil Branch Piping: Insulate chilled water piping and associated components up to coil connection.
3. Condensate Piping: Insulate entire piping system and components to prevent condensation.

I. Closed Cell Elastomeric Insulation:

1. Push insulation on to piping.
2. Miter joints at elbows.
3. Seal seams and butt joints with manufacturer’s recommended adhesive.
4. When application requires multiple layers, apply with joints staggered.
5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.

J. High Temperature Pipe Insulation:

1. Install in multiple layers to meet thickness scheduled.
2. Attach each layer with bands. Secure first layer with bands before installing next layer.
3. Stagger joints between layers.
4. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

K. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above

finished floor): Finish with canvas jacket sized for finish painting.

L. Piping Exterior to Building: Provide vapor retarder jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor retarder cement. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water or on bottom side of horizontal piping.

M. Buried Piping: Insulate only where insulation manufacturer recommends insulation product may be installed in trench, tunnel or direct buried. Install factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with 1 mil thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with polyester film.

N. Heat Traced Piping Interior to Building: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer.

O. Heat Traced Piping Exterior to Building: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size insulation large enough to enclose pipe and heat tracer. Cover with aluminum stainless steel jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water.

P. Prepare pipe insulation for finish painting.

3.3 INSTALLATION - DUCTWORK SYSTEMS

A. Insulated ductwork conveying air below ambient temperature:

1. Provide insulation with vapor retarder jackets.
2. Finish with tape and vapor retarder jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

B. Insulated ductwork conveying air above ambient temperature:

1. Provide with or without standard vapor retarder jacket.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

C. Ductwork Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet above finished floor): Finish with canvas jacket sized for finish painting.

D. External Glass Fiber Duct Insulation:

1. Secure insulation with vapor retarder with wires and seal jacket joints with vapor retarder adhesive or tape to match jacket.

2. Secure insulation without vapor retarder with staples, tape, or wires.
3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
4. Seal vapor retarder penetrations by mechanical fasteners with vapor retarder adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

E. External Elastomeric Duct Insulation:

1. Adhere to clean oil-free surfaces with full coverage of adhesive.
2. Seal seams and butt joints with manufacturer's recommended adhesive.
3. When application requires multiple layers, apply with joints staggered.
4. Insulate standing metal duct seams with insulation of like material and thickness as adjacent duct surface. Apply adhesive at joints with flat duct surfaces.
5. Lift ductwork off trapeze hangers and insert spacers.

F. Duct and Plenum Liner:

1. Adhere insulation with adhesive for 90-100 percent coverage.
2. Secure insulation with mechanical liner fasteners. Comply with SMACNA Standards for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Cut insulation for tight overlapped corner joints. Support top pieces of liner at edges with side pieces.

G. Ducts Exterior to Building:

1. Install insulation according to duct liner paragraph above.
2. Provide external insulation with vapor retarder jacket. Cover with outdoor jacket finished with caulked aluminum jacket with seams located on bottom side of horizontal duct section.
3. Finish with aluminum duct jacket.
4. Calk seams at flanges and joints. Located major longitudinal seams on bottom side of horizontal duct sections.

H. Prepare duct insulation for finish painting.

3.4 INSTALLATION - EQUIPMENT

A. Factory Insulated Equipment: Do not insulate.

B. Exposed Equipment: Locate insulation and cover seams in least visible locations.

C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

D. Equipment Containing Fluids Below Ambient Temperature:

1. Insulate entire equipment surfaces.
2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
4. Finish insulation at supports, protrusions, and interruptions.

E. Equipment Containing Fluids 140 degrees or Less:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation.
2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
3. Finish insulation at supports, protrusions, and interruptions.

F. Equipment Containing Fluids Over 140 degrees F:

1. Insulate flanges and unions with removable sections and jackets.
2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
3. Finish insulation at supports, protrusions, and interruptions.

G. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting or PVC jacket and fitting covers.

H. Equipment Located Exterior to Building: Install vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.

I. Cover insulation with aluminum jacket.

J. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.

K. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.

3.5 SCHEDULES

A. Cooling Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches
Chilled Water Supply and Return 40 to 60 degrees F	P-1	Less than 4 inches 4 inches and larger	1.5 3.0
Chilled Water Supply and Return less than 40 degrees F	P-1	3/4 inch and smaller 1 inch to 6 inches 8 inches and larger	1.5 2.0 3.0
Condensate Piping from Cooling Coils	P-5	All sizes	0.5
Refrigerant Suction	P-5	All sizes	1.0
Refrigerant Hot Gas	P-5	All sizes	1.0

B. Heating Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches
Heating Water Supply and Return 105 to 140 degrees F	P-1	1 inch and smaller Greater than 1 inch	1.0 1.5
Heating Water Supply and Return 141 to 200 degrees F	P-1	Less than 1-1/2 inches 1-1/2 inches and larger	1.5 2.0
Heating Water Supply and Return 201 to 250 degrees F	P-1	Less than 4 inches 4inches and larger	2.5 3.0
Heating Water Supply and Return 251 to 350 degrees F	P-1	Less than 1 ½ inches 1 ½ inches and larger	4.0 4.5
Heating Water Supply and Return Above 350 degrees F	P-1	1 inch and less Greater than 1 inch	4.5 5.0
Humidifier Supply Piping	P-1	2 inches and smaller 2-1/2 inches and larger	1.5 2.0
Humidifier Drain Piping	P-1	All sizes	1.0

C. Ductwork Insulation Schedule:

DUCTWORK SYSTEM	INSULATION TYPE	INSULATION THICKNESS inches
Combustion Air	D-2	1.5
Outside Air Intake	D-2	1.5
Equipment Casings	D-2	1.0
Supply Ducts (internally insulated)	D-4 or D-5	1.0
Return Ducts (internally insulated)	D-4 or D-5	1.0
Supply Ducts (externally insulated) Thickness indicated is installed thickness.	D-1 or D-2	1.5
Return Ducts (externally insulated) Thickness indicated is installed thickness.	D-1 or D-2	1.5
Duct Coils	D-1	1.0
Supply Air, Return Air, (exterior to building on roof)	D-2	2.5
Rectangular Supply Ducts Downstream of Variable Air Volume Boxes (internally insulated)	D-4 or D-5	1.0
Rectangular Supply Ducts Downstream of Variable Air Volume Boxes (externally insulated)	D-1 or D-2	1.5
Round Supply Ducts Downstream of Variable Air Volume Boxes (externally insulated)	D-1 or D-2	1.5
Transfer Air Ducts (internally insulated)	D-4 or D-5	1.0

D. Equipment Insulation Schedule:

EQUIPMENT SYSTEM	INSULATION TYPE	INSULATION THICKNESS inches
Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, nozzles and other areas recommended by manufacturers	Cellular Glass (E-5) Mineral-Fiber Board (E-2, 3 ,4) Mineral-Fiber Pipe and Tank (E-9)	2.0 1.0 1.0

Heat-exchanger (water-to-water for cooling service) insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2, 3) Mineral-Fiber Pipe and Tank (E-9)	2.0 1.0 1.0
Heat-exchanger (water-to-water for heating service) insulation	Calcium Silicate (E-7) Cellular Glass (E-5) Mineral-Fiber Board (E-2,3) Mineral-Fiber Pipe and Tank (E-9)	3.0 3.0 2.0 2.0
Chilled-water pump insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2, 3)	3.0 2.0
Condenser-water pump insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2, 3)	3.0 2.0
Heating-hot-water pump insulation	Calcium Silicate (E-7) Cellular Glass (E-5) Mineral-Fiber Board (E-2) Mineral-Fiber Pipe and Tank (E-9)	3.0 3.0 2.0 2.0
Chilled-water expansion/compression tank insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2) Mineral-Fiber Pipe and Tank (E-9)	2.0 1.0 1.0
Heating-hot-water expansion/compression tank insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2)	3.0 2.0
Chilled-water air-separator insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2) Mineral-Fiber Pipe and Tank (E-9)	2.0 1.0 1.0
Condenser-water air-separator insulation	Cellular Glass (E-5) Mineral-Fiber Board (E-2) Mineral-Fiber Pipe and Tank (E-9)	2.0 1.0 1.0

Heating-hot-water air-separator	Cellular Glass (E-5) Mineral-Fiber Board (E-2)	3.0 2.0
Thermal storage tank (ice insulation)	Calcium Silicate (E-7)	3.0

END OF SECTION 23 07 00

SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC Commissioning description.
2. HVAC Commissioning responsibilities.

1.2 REFERENCES

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE Guideline 0 - The Commissioning Process.
2. ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process.

B. Associated Air Balance Council:

1. AABC Commissioning Guidelines.

1.3 COMMISSIONING DESCRIPTION

A. HVAC commissioning process includes the following tasks:

1. Testing and startup of HVAC equipment and systems.
2. Equipment and system verification checks.
3. Assistance in functional performance testing to verify testing and balancing, and equipment and system performance.
4. Provide qualified personnel to assist in commissioning tests, including seasonal testing.
5. Complete and endorse functional performance test checklists provided by Commissioning Authority to assure equipment and systems are fully operational and ready for functional performance testing.
6. Provide equipment, materials, and labor necessary to correct deficiencies found during commissioning process to fulfill contract and warranty requirements.
7. Provide operation and maintenance information and record drawings to Commissioning Authority for review verification and organization, prior to distribution.
8. Provide assistance to Commissioning Authority to develop, edit, and document system operation descriptions.
9. Provide training for systems specified in this Section with coordination by Commissioning Authority.

B. Equipment and Systems to Be Commissioned:

1. Chilled Water and Low Temperature Heating Hot Water Pumps
2. Chilled Water and Low Temperature Heating Hot Water Piping systems.
3. Ductwork.
4. Variable frequency drives.

5. Packaged roof top air conditioning units.
6. Split system air conditioning units.
7. Humidifiers.
8. Air handling units.
9. Packaged heat pump units.
10. Self-contained air conditioning units.
11. Fan Coil Units.
12. Heat exchangers.
13. Computer room units.
14. Constant volume terminal units.
15. Variable volume terminal units.
16. Fans.
17. Fire dampers.
18. Smoke dampers.
19. Indoor air quality.
20. Equipment sound control.
21. Equipment vibration control.
22. Automatic temperature control system.
23. Testing, Adjusting and Balancing work.
24. Chillers.
25. Boilers
26. Cooling Towers.
27.

1.4 COMMISSIONING SUBMITTALS

A. Draft Forms: Submit draft of system verification form and functional performance test checklist.

B. Test Reports: Indicate data on system verification form for each piece of equipment and system as specified. Use AABC or forms.

C. Field Reports: Indicate deficiencies preventing completion of equipment or system verification checks equipment or system to achieve specified performance.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record revisions to equipment and system documentation necessitated by commissioning.

B. Operation and Maintenance Data: Submit revisions to operation and maintenance manuals when necessary revisions are discovered during commissioning.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with ASHRAE Guideline 0.

B. Perform Work in accordance with ASHRAE Guideline 1.1.

1.7 COMMISSIONING RESPONSIBILITIES

A. See Specifications Section 01 91 00 for the commissioning responsibilities.

1.8 COMMISSIONING MEETINGS

A. Attend initial commissioning meeting and progress commissioning meetings as required by Commissioning Authority.

1.9 SCHEDULING

A. Prepare schedule indicating anticipated start dates for the following:

1. Piping system pressure testing.
2. Piping system flushing and cleaning.
3. Ductwork cleaning.
4. Ductwork pressure testing.
5. Equipment and system startups.
6. Automatic temperature control system checkout.
7. Testing, adjusting, and balancing.
8. HVAC system orientation and inspections.
9. Operation and maintenance manual submittals.
10. Training sessions.

B. Schedule seasonal tests of equipment and systems during peak weather conditions to observe full-load performance.

C. Schedule occupancy sensitive tests of equipment and systems during conditions of both, minimum and maximum occupancy or use.

1.10 COORDINATION

A. Notify Commissioning Authority minimum of four weeks in advance of the following:

1. Scheduled equipment and system startups.
2. Scheduled automatic temperature control system checkout.
3. Scheduled start of testing, adjusting, and balancing work.

Coordinate programming of automatic temperature control system with construction and commissioning schedules.

PART 2 - PRODUCTS

2.1 DESIGN DOCUMENT AND SUBMITTAL REVIEWS

A. General:

1. Review the Owner Project Requirements (OPR) and relevant design documents.

2.2 SEQUENCE OF OPERATIONS OF HVAC SYSTEM

A. General:

1. Sequences of Operation submittal shall describe in details the operation of the building control system and its components. The Sequences and the Specifications shall provide a good overview or the HVAC operation and controls. Sequences should address all critical system interactions in detail to enable their verification and troubleshooting. Changes to the Sequence during the commissioning shall be documented and As Built Sequence shall be issued for LAWA review and approval.

2.3 START-UP AND TESTING, ADJUSTING AND BALANCING (TAB) REPORTS

A. Start-up and testing reports shall be generated by the installing contractor for all equipment/systems and submitted to Contractor who provides a copy to the Commissioning Authority (CxA).

B. TAB reports shall be created for designated systems by a certified TAB provider and submitted to Contractor who provides a copy to the CxA.

2.4 FUNCTIONAL PERFORMANCE TESTS

A. General:

1. Submit Functional Performance Test forms for LAWA approvals.

2. Submit Functional Performance Test results for each system.

2.5 OPERATION & MAINTENANCE MANUAL AND PERSONNEL TRAINING REVIEWS

A. Submit O&M Manuals and Personnel Training Reviews.

2.6 SYSTEMS MANUAL

A. Submit Systems Manual.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install additional balancing dampers, balancing valves, access doors, test ports, and pressure and temperature taps required by Commissioning Authority or commissioning plan.

B. Place HVAC systems and equipment into full and continue operation during each working day of commissioning.

C. Install replacement sheaves and belts to obtain system performance, as requested by Commissioning Authority.

D. Install test holes in ductwork and plenums as requested by Commissioning Authority for taking air measurements.

E. Prior to start of functional performance test, install replacement filters in equipment.

3.2 COMMISSIONING

A. Seasonal Functional Performance Tests (as far as possible and in consultation with LAWA) shall include:

1. Test heating equipment at winter design temperatures.

2. Test cooling equipment at summer design temperatures.

B. Commissioning Authority (CxA) shall conduct initial and alternate peak season test of systems required to demonstrate performance.

C. Occupancy Functional Performance Tests:

1. Test equipment and systems affected by occupancy variations at the minimum and the peak loads to observe system performance.

2. If required, testing could be delayed beyond Final Completion, to test performance with actual occupancy conditions.

3.3 DEMONSTRATION AND TRAINING.

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Furnish services of the trained representatives from equipment manufacturers to instruct LAWA on operation and maintenance of HVAC Equipment and Systems. Training to include minimum of 8 LAWA personnel for 40 hours training, 16 hours shall be classroom training per person and 24 hours shall be hands-on training per person. The Commissioning Authority shall witness and record the training activities.

END OF SECTION 23 08 00

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heating water piping, above ground.
2. Chilled water piping and condenser water piping, above grade.
3. Equipment drains and over flows.
4. Unions and flanges.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B16.3 - Malleable Iron Threaded Fittings.
2. ASME B16.4 - Gray Iron Threaded Fittings.
3. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
4. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
5. ASME B31.1 - Power Piping.
6. ASME B31.9 - Building Services Piping.
7. ASME Section IX - Boiler and Pressure Vessel Code - Welding and Brazing Qualifications.

B. ASTM International:

1. ASTM A53 / A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A234 / A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
3. ASTM A395 / A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
4. ASTM A536 - Standard Specification for Ductile Iron Castings.
5. ASTM B32 - Standard Specification for Solder Metal.
6. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
7. ASTM B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

C. American Welding Society:

1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
2. AWS D1.1 - Structural Welding Code - Steel.

1.3 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, provide compatible system components and joints. When joining dissimilar metals piping use Brass ball valve and 6 inch long Brass nipples for 1-1/2" inch and larger. Provide flanges, union, and couplings at locations requiring servicing. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

B. Provide pipe hangers and supports in accordance with these specifications and drawings.

C. Flexible Connectors: Use at or near pumps and motor driven equipment where piping configuration does not absorb vibration.

1.4 SUBMITTALS

A. Product Data:

1. Piping: Submit data on pipe materials, fittings, and accessories. Submit manufacturers catalog information.

B. Welding certificates.

C. Qualification Data: For installer.

1.5 QUALITY ASSURANCE

A. Qualification for Welders: Welders performing work under this Contract shall be certified and qualified in accordance with tests prescribed by the National Certified Welding Bureau (NCWB) or by other approved test procedures using methodology and procedures covered in the ASME Boiler and Pressure Vessel Code, Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

1. Submit for approval the names, identification, and welder's assigned number, letter or symbol of welders assigned to this project.
2. The assigned identification symbol shall be used to identify the work of each welder and shall be marked with an indelible paint marking pen upon completion of each weld.
3. Welders shall be tested and certified for all positions, per NCPWB or AWS.
4. Submit identifying stenciled test coupons made by each operator to NCPWB or AWS when testing is required.
5. Any or all welders may be required to retake welding certification tests without additional expense.
6. When so requested, a welder shall not be permitted to work as a welder on this project until he has been recertified in accordance with NCPWB or AWS.
7. Recertification of the welder shall be made after the welder has taken and passed the required tests.
8. When piping 1-1/2 in. and smaller is butt or socket welded, follow NCPWB or AWS testing procedures, or submit three samples of test welds for approval.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed NWPCB or AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 HEATING WATER PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A53 / A53M, Schedule 40 STD, 0.375 inch wall for sizes 12 inch and larger, black.

1. Fittings: ASME B16.3, malleable iron or ASTM A234 / A234M, forged steel welding type.
2. Joints: Threaded for pipe 2 inches and smaller; welded for pipe 2-1/2 inches and larger.

B. Steel Pipe: ASTM A53 / A53M, Schedule 40, 0.375 inch wall for sizes 12 inch and larger, black, grooved ends.

1. Fittings: ASTM A234 / A234M carbon steel, grooved ends.
2. Joints: Grooved mechanical couplings meeting ASTM F1476.
    a. Housing Clamps: ASTM A395 / A395M and ASTM A536 ductile iron, compatible with steel piping sizes.
    b. Gasket: Elastomer composition for operating temperature range from -30 degrees F to 230 degrees F.
    c. Accessories: Steel bolts, nuts, and washers.

C. Copper Tubing: ASTM B88, Type L drawn.

1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.
2. Joints: Solder, lead free, ASTM B32, Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

2.2 CHILLED WATER PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A53 / A53M, Schedule 40, black, 0.375 inch wall for sizes 12 inch and larger, black.

1. Fittings: ASME B16.3, malleable iron or ASTM A234 / A234M, forged steel welding type.
2. Joints: Threaded for pipe 2 inches and smaller; welded for pipe 2-1/2 inches and larger.

B. Steel Pipe: ASTM A53 / A53M Schedule 40, black, cut rolled grooved ends.

1. Fittings: ASTM A395 / A395M and ASTM A536 ductile iron, or ASTM A234 / A234M carbon steel, grooved ends.
2. Joints: Grooved mechanical couplings meeting ASTM F1476.

a. Housing Clamps: ASTM A395 / A395M and ASTM A536 ductile iron, compatible with steel piping sizes, rigid type.

b. Gasket: Elastomer composition for operating temperature range from -30 degrees F to 230 degrees F.

c. Accessories: Steel bolts, nuts, and washers.

C. Copper Tubing: ASTM B88, Type L drawn.

1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.

2. Joints: Solder, lead free, ASTM B32, Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

2.3 EQUIPMENT DRAINS AND OVERFLOWS

A. Steel Pipe: ASTM A53 / A53M Schedule 40, galvanized.

1. Fittings: ASME B16.3, malleable iron or ASME B16.4, cast iron.

2. Joints: Threaded for pipe 2 inches and smaller; flanged for pipe 2-1/2 inches and larger.

B. Steel Pipe: ASTM A53 / A53M Schedule 40, galvanized or painted, grooved ends.

1. Fittings: ASTM A395 / A395M and ASTM A536 ductile iron, grooved ends.

2. Joints: Grooved mechanical couplings meeting ASTM F1476.

a. Housing Clamps: ASTM A395 / A395M and ASTM A536 ductile iron, compatible with steel piping sizes, rigid type.

b. Gasket: Elastomer composition for operating temperature range from -30 degrees F to 230 degrees F.

c. Accessories: Steel bolts, nuts, and washers.

C. Copper Tubing: ASTM B88, Type DWV or L, drawn.

1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.

2. Joints: Solder, lead free, ASTM B32.

2.4 UNIONS AND FLANGES

A. Unions for Pipe 2 inches and Smaller:

1. Ferrous Piping: Class 150, malleable iron, threaded.

2. Copper Piping: Class 150, bronze unions with soldered joints.

3. Dissimilar Materials: Brass ball valve and 6 inch long Brass nipple.

B. Flanges for Pipe 2-1/2 inches and Larger:

1. Ferrous Piping: Class 150, forged steel, slip-on flanges.

2. Copper Piping: Class 150, slip-on bronze flanges.

3. Gaskets: 1/16 inch thick preformed neoprene gaskets.

4. Dissimilar Materials: Brass ball valve and 6 inch long Brass nipple.

PART 3 - EXECUTION

3.1 INSTALLATION - INSERTS

A. Provide inserts for placement in concrete forms.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger, casting anchor or anchor inserts.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

3.2 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Support horizontal piping per table - Copper & Steel.

B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

C. Place hangers within 12 inches of each horizontal elbow, 12 inches from end of fitting.

D. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

E. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.

F. Where installing several pipes in parallel and at same elevation, provide multiple pipe hangers or trapeze hangers.

G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

3.3 INSTALLATION - ABOVE GROUND PIPING SYSTEMS

A. Route piping parallel to building structure and maintain gradient.

B. Install piping to conserve building space, and not interfere with use of space.

C. Group piping whenever practical at common elevations.

D. Sleeve pipe passing through partitions, walls and floors.

E. Install firestopping at fire rated construction perimeters and openings containing penetrating sleeves and piping.

F. Install pipe identification.

G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

H. Coordinate with General Contractor to provide access where valves and fittings are not exposed.

I. Horizontal hydronic piping to run level. Drain systems at low points. Use eccentric reducers or concentric to reduce pipe, maintain top of pipe aligned, when possible.

J. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

K. Prime unfinished pipe, fittings, supports, and accessories, ready for finish painting.

L. Install valves with stems upright or horizontal, not inverted.

M. Insulate piping as required.

3.4 FIELD QUALITY CONTROL

A. Test all piping to at least 150% of working pressure for minimum of two hours.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests on hydronic piping:

1. Verify that pipe is clean and free of debris and has been completed.
2. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
3. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
4. Isolate expansion tanks and determine that hydronic system is full of water.
5. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
6. After hydrostatic test pressure has been applied for at least 2 hours, with system valves capped and pressure apparatus disconnected, and no change in test pressure, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
7. Prepare written report of testing.

3.6 ADJUSTMENT AND CLEANING

A. Cleaning:

1. During construction, prevent entry of foreign matter, clean pipe, fittings, and valves internally and hammer welds to remove all loose dirt, mill scale, metal chips, weld beads rust and harmful substances. Flush piping system with clear water prior to connection to coils, control valves and equipment. Install temporary strainer or by-pass piping around factory cleaned components such as coils, control valves and equipment where piping system is not flushed prior to connection. Remove temporary strainer or by-pass piping before LAWA final acceptance.
2. Flush with clear water and seal ends after cleaning.
3. Water Systems:
    a. Open all valves, drains, vents and strainers at all system levels.
    b. Remove plugs, caps, spool pieces and components to facilitate early debris discharge from system.
    c. Isolate or protect clean systems components including pumps and pressure vessels and remove any component that may be damaged. Install temporary strainer where necessary.
    d. Flush bottoms of risers.
    e. After start-up flushing, fill with clean water, add products recommended by water treatment supplier to remove adherent organic soil, hydrocarbon flux, pipe mill varnish, joint compounds, rust and harmful substances not removed by initial flushing.
    f. Circulate water of each system at respective design flow rates for at least 8 hours.
    g. At end of 8 hour period, remove and clean strainers and blow off low point, then completely drain out entire systems of cleaning solution.
    h. Refill systems with clean water and circulate for an additional 4 hour period and, at the end of that interval, completely drain systems, operate all valves to dislodge debris.
    i. Drain, refill with clear water and circulate, and provide water treatment as directed by the water treatment company.
4. Do not circulate water to the Central Utility Plant (CUP) until the CUP water treatment contractor has certified the water quality in both, the CUP and the water distribution systems.

END OF SECTION 23 21 13

SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pressure gages.
2. Pressure gage taps.
3. Thermometers.
4. Thermometer supports.
5. Test plugs.
6. Air vents.
7. Strainers.
8. Flow controls.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element.
2. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.

B. ASTM International:

1. ASTM E1 - Standard Specification for ASTM Thermometers.
2. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers.

1.3 SUBMITTALS

A. Product Data: Submit for manufactured products and assemblies used in this Project.

1. Manufacturer's data and list indicating use, operating range, total range, accuracy, and location for manufactured components.
2. Submit product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.
3. Submit schedule indicating manufacturer, model number, size, location, rated capacity, load served, and features for each piping specialty.
4. Submit electrical characteristics and connection requirements where appropriate.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit instructions for calibrating instruments, installation instructions, assembly views, servicing requirements, lubrication instruction, and replacement parts list.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary protective coating on cast iron and steel valves.

B. Protect systems from entry of foreign materials by temporary covers, caps and closures, completing sections of the work, and isolating parts of completed system until installation.

PART 2 - PRODUCTS

2.1 PRESSURE GAGES

A. Manufacturers:
   1. **Trerice.**
   2. **Dwyer .**
   3. **Ashcroft.**

B. Gage: ASME B40.1, UL Listed with bourdon tube, rotary brass movement, brass socket, front calibration adjustment, black scale on white background.
   1. Case: Steel.
   2. Bourdon Tube: Brass.
   3. Dial Size: 2 inch diameter minimum.
   4. Mid-Scale Accuracy: One percent.
   5. Scale: PSI.

2.2 PRESSURE GAGE TAPS

A. Manufacturers:
   1. **Trerice.**
   2. **Dwyer**
   3. **Ashcroft.**

B. Valve: Brass, 1/4 inch NPT for minimum 300 psi.

C. Ball Valve: Brass 1/4 inch NPT for 250 psi.

D. Pulsation Damper: Pressure snubber, brass with 1/4 inch NPT connections.

2.3 STEM TYPE THERMOMETERS

A. Manufacturers:
   1. **Trerice.**
   2. **Dwyer**
   3. **Ashcroft**

B. Thermometer: ASTM E1, red appearing mercury, lens front tube, cast aluminum case with enamel finish.
   1. Size: 9 inch scale.
   2. Window: Clear glass or Lexan.
   3. Stem: Brass, 3/4 inch NPT long.
   4. Accuracy: ASTM E77 2 percent.
   5. Calibration: Degrees F.

C. Thermometer: ASTM E1, adjustable angle, red appearing mercury, lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device.
   1. Size: 9 inch scale.
   2. Window: Clear glass or Lexan.
   3. Stem: Brass, 3/4 inch NPT long.
   4. Accuracy: ASTM E77 2 percent.
   5. Calibration: Degrees F.

2.4 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions, and with cap and chain.

B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.5 TEST PLUGS

A. Manufacturers:
   1. **Trerice.**
   2. **Peterson Equipment.**
   3. **Watts Industries.**

B. 1/4 inch NPT or 1/2 inch NPT brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with:
   1. Neoprene core for temperatures up to 200 degrees F.
   2. Nordel core for temperatures up to 350 degrees F.
   3. Viton core for temperatures up to 400 degrees F.

C. Test Kit:

1. Carrying case, internally padded and fitted containing:

a. Two 2-1/2 inch diameter pressure gages.

2.6 AIR VENTS

A. Manufacturers:

1. **Trerice.**
2. **Peterson Equipment.**
3. **Watts Industries.**

B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

C. Float Type:

1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

D. Washer Type:

1. Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.7 STRAINERS

A. Manufacturers:

1. **Nibco.**
2. **Milwaukee.**
3. **Zurn-Wilkins.**

B. Size 2 inch and Smaller:

1. Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

C. Size 2-1/2 inch to 4 inch:

1. Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

D. Size 5 inch and Larger:

1. Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.8 FLOW CONTROLS

A. Manufacturers:
   1. **Griswold.**
   2. **Bell & Gossett.**
   3. **Tour and Andersson**

B. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet combination blow-down and back-flush drain.

C. Calibration: Control within 5 percent of design flow over entire operating pressure.

D. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.

E. Accessories: In-line strainer on inlet and ball valve on outlet.

PART 3 - EXECUTION

3.1 INSTALLATION - THERMOMETERS AND GAGES

A. Install one pressure gage for each pump, locate taps before strainers and on suction and discharge of pump; pipe to gage.

B. Install gage taps in piping

C. Install pressure gages with pulsation dampers. Provide needle valve or ball valve to isolate each gage. Extend nipples to allow clearance from insulation.

D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches for installation of thermometer sockets. Allow clearance from insulation.

E. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets. Where thermometers are provided on local panels, pipe mounted thermometers are not required.

F. Coil and conceal excess capillary on remote element instruments.

G. Provide instruments with scale ranges selected according to service with largest appropriate scale.

H. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

I. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.

3.2 INSTALLATION - HYDRONIC PIPING SPECIALTIES

A. Where large air quantities accumulate, provide enlarged air collection standpipes.

B. Install manual air vents at system high points.

C. For automatic air vents in ceiling spaces or other concealed locations, install vent tubing to nearest drain.

D. Provide drain and hose connection with valve on strainer blow down connection.

3.3 PROTECTION OF INSTALLED CONSTRUCTION

A. Do not install hydronic pressure gauges until after systems are pressure tested.

END OF SECTION 23 21 16

SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line circulators.
2. Close coupled pumps.

1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

B. Underwriters Laboratories Inc.:

1. UL 778 - Motor Operated Water Pumps.

1.3 PERFORMANCE REQUIREMENTS

A. Provide pumps to operate at system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

1.4 SUBMITTALS

A. Product Data: Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements. Submit also: manufacturer model number, dimensions, service sizes, and finishes.

PART 2 - PRODUCTS

2.1 IN-LINE CIRCULATORS

A. Manufacturers:

1. **Bell & Gossett.**
2. **Armstrong.**
3. **Taco.**

B. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 125 psig maximum working pressure.

C. Casing: Cast iron, with flanged pump connections.

D. Impeller: Stamped brass or cast bronze, keyed to shaft.

E. Bearings: Two, oil lubricated bronze sleeves.

F. Shaft: Alloy or stainless steel with copper or bronze sleeve, integral thrust collar.

G. Seal: Carbon rotating against stationary ceramic seat.

H. Drive: Flexible coupling.

2.2 CLOSE COUPLED PUMPS

A. Manufacturers:
1. **Bell & Gossett.**
2. **Armstrong.**
3. **Taco.**

B. Type: Horizontal shaft, single stage, close coupled, radial split casing, for 175 psig maximum working pressure.

C. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

D. Impeller: Bronze, fully enclosed, keyed to motor shaft extension.

E. Shaft: Stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide pumps to operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

B. Install long radius reducing elbows or reducers between pump and piping. Support piping adjacent to pump so no weight is carried on pump casings. For close coupled or base mounted pumps, install supports under elbows on pump suction and discharge line sizes 4 inches and over.

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump so no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 4 inches and larger.

D. Provide air cock and drain connection on horizontal pump casings.

E. Provide drains for bases and seals.

F. Check, align, and certify alignment of base mounted pumps prior to start-up.

G. Provide 1 year warranty.

H. Provide O & M Manuals to LAWA.

END OF SECTION 23 21 23

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Refrigerant piping.
2. Unions, flanges, and couplings.
3. Pipe hangers and supports.
4. Refrigerant moisture and liquid indicators.
5. Valves.
6. Refrigerant strainers.
7. Refrigerant pressure regulators.
8. Refrigerant pressure relief valves.
9. Refrigerant filter-driers.
10. Refrigerant solenoid valves.
11. Refrigerant expansion valves.
12. Electronic expansion valves.
13. Refrigerant receivers.
14. Underground pipe markers.
15. Bedding and cover materials.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 495 - Refrigerant Liquid Receivers.
2. ARI 710 - Liquid-Line Driers.
3. ARI 730 - Flow-Capacity Rating and Application of Suction-Line Filters and Filter Dryers.
4. ARI 750 - Thermostatic Refrigerant Expansion Valves.
5. ARI 760 - Solenoid Valves for Use with Volatile Refrigerants.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 15 - Safety Code for Mechanical Refrigeration.

C. American Society of Mechanical Engineers:

1. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
2. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.

3. ASME B31.5 - Refrigeration Piping.
4. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.

D. ASTM International:

1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
3. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
4. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
5. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
6. ASTM B749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.

E. American Welding Society:

1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
2. AWS D1.1 - Structural Welding Code - Steel.

F. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

G. Underwriters Laboratories Inc.:

1. UL 429 - Electrically Operated Valves.

1.3 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, provide compatible system components and joints. Use brass ball valve and 6” long brass nipple when joining dissimilar metals in the systems.

B. Provide flanges, unions, or couplings at locations requiring servicing. Use unions, flanges, or couplings downstream of valves and at equipment connections. Do not use direct welded or threaded connections to valves or equipment.

C. Provide receivers on systems if recommended by equipment supplier.

D. Flexible Connectors: Use at or near compressors where piping configuration does not absorb vibration.

1.4 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig.
2. Suction Lines for Heat-Pump Applications: 380 psig.
3. Hot-Gas and Liquid Lines: 380 psig.

B. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.5 SUBMITTALS

A. Shop Drawings: Indicate layout of refrigeration piping system, including equipment, critical dimensions, and sizes.

B. Product Data:

1. Piping: Submit data on pipe materials, fittings, and accessories.
2. Valves: Submit manufacturers catalog information with valve data and ratings for each service.
3. Hangers and Supports: Submit manufacturers catalog information including load capacity.
4. Refrigerant Specialties: Submit manufacturers catalog information including capacity, component sizes, rough-in requirements, and service sizes for the following:
    a. Refrigerant. Type.
    b. Refrigerant moisture and liquid indicators.
    c. Refrigerant strainers.
    d. Refrigerant pressure regulators.
    e. Refrigerant pressure relief valves.
    f. Refrigerant filter-driers.
    g. Refrigerant solenoid valves.
    h. Refrigerant expansion valves.
    i. Electronic expansion valves.

C. Design Data: Indicate pipe size. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.

D. Test Reports: Indicate results of refrigerant leak test.

E. Manufacturer's Installation Instructions: Submit hanging and support methods, joining procedures and isolation.

F. Welding Certificates.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

A. Copper Tubing: ASTM B280, drawn

B. Fittings: ASME B16.22 wrought copper ASTM B16.26 Cast Copper.

1. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

2.2 UNIONS, FLANGES, AND COUPLINGS

A. 2 inches and Smaller:

1. Ferrous Piping: 150 psig malleable iron, threaded.
2. Copper Pipe: Bronze, soldered joints.

2.3 PIPE HANGERS AND SUPPORTS

A. Manufacturers:

1. **B-Line.**
2. **Tolco.**
3. **PHD.**

B. Conform to ASME B31.5.

C. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, Carbon steel, adjustable swivel, split ring.

D. Hangers for Cold Pipe Sizes 2 inches and Larger: Carbon steel, adjustable, clevis.

E. Hangers for Hot Pipe Sizes 2 to 4 inches: Carbon steel, adjustable, clevis.

F. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

G. Wall Support for Pipe Sizes 3 inches and Smaller: Cast iron hooks.

H. Vertical Support: Steel riser clamp.

I. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

J. Floor Support for Hot Pipe 4 inches and Smaller: Adjustable hanger or strut system, floor flange, and concrete pier or steel support.

K. Copper Pipe Support: Carbon steel rings, adjustable, copper plated.

L. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

M. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

N. Sheet Lead: ASTM B749.

2.4 REFRIGERANT MOISTURE AND LIQUID INDICATORS

A. Manufacturers:
1. **Alco Controls Div, Emerson Electric Co.**
2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Indicators:
1. Port: Single or Double, UL listed.
2. Body: Copper or brass, flared or solder ends.
3. Sight glass: Color-coded paper moisture indicator with removable element cartridge and plastic cap.
4. Maximum working pressure: 500 psig
5. Maximum working temperature: 200 degrees F.

2.5 VALVES

A. Manufacturers:
1. **Alco Controls Div, Emerson Electric Co.**
2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Diaphragm Packless Valves:
1. UL listed, globe or angle pattern, forged brass body and bonnet solder or flared ends.
2. Phosphor bronze and stainless steel diaphragms, rising stem and hand wheel.
3. Stainless steel spring, nylon seats, disc with positive back seating.
4. Maximum working pressure: 500 psig.
5. Maximum working temperature: 275 degrees F.

C. Packed Angle Valves:
1. Forged brass or nickel-plated forged steel, solder or flared ends.
2. Forged brass seal caps with copper gasket, rising stem and seat, molded stem packing.
3. Maximum working pressure: 500 psig.
4. Maximum working temperature: 275 degrees F.

D. Ball Valves:

1. Two-piece bolted forged brass body with Teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals, soldered or threaded ends.
2. Maximum working pressure: 500 psig.
3. Maximum working temperature: 325 degrees F.

E. Service Valves:

1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or solder ends.
2. Maximum working pressure: 500 psig.

F. Refrigerant Check Valves:

1. Manufacturers:
   a. **Alco Controls Div, Emerson Electric Co.**
   b. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
   c. **Sporlan Valve Division / Parker Hannifin Corporation.**
2. Globe Type:
   a. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, Teflon seat disc.
   b. Maximum working pressure: 500 psig.
   c. Maximum working temperature: 300 degrees F.
3. Straight Through Type:
   a. Spring, neoprene seat.
   b. Maximum working pressure: 500 psig.
   c. Maximum working temperature: 250 degrees F.

2.6 REFRIGERANT STRAINERS

A. Manufacturers:

1. **Alco Controls Div, Emerson Electric Co.**
2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Straight Line or Angle Line Type:

1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or Monel reinforced with brass.
2. Maximum working pressure: 430 psig.

C. Straight Line, Non-Cleanable Type:

1. Steel shell, copper plated fittings, stainless steel wire screen.

2.7 REFRIGERANT PRESSURE REGULATORS

A. Manufacturers:
   1. **Alco Controls Div, Emerson Electric Co.**
   2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
   3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Brass body, stainless steel diaphragm, direct acting or pilot operated with remote pressure pilot, adjustable over 0 to 80 psig range, for maximum working pressure of 450 psig.

2.8 REFRIGERANT PRESSURE RELIEF VALVES

A. Manufacturers:
   1. **Alco Controls Div, Emerson Electric Co.**
   2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
   3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB; for standard 425 psig setting; selected to ASHRAE 15.

2.9 REFRIGERANT FILTER-DRIERS

A. Manufacturers:
   1. **Alco Controls Div, Emerson Electric Co. Mo**
   2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
   3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Replaceable Cartridge Angle Type:
   1. Shell: ARI 710, UL listed, brass, steel, removable cap, for maximum working pressure of 500 psig, inches outside diameter size connections.
   2. Filter Cartridge: Pleated media with integral end rings, stainless steel support, ARI 730 rating.
   3. Filter/Dryer Cartridge: Pleated media with solid core sieve with activated alumina, ARI 730 rating.
   4. Wax Removal Cartridge: Molded bonded core of activated charcoal with integral gaskets, ARI 710 moisture rating.

2.10 REFRIGERANT SOLENOID VALVES

A. Manufacturers:
   1. **Alco Controls Div, Emerson Electric Co.**
   2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
   3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Valve: ARI 760, pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly, integral strainer, with flared, solder, or threaded ends; for maximum working pressure of 500 psig. Stem designed to allow manual operation in case of coil failure.

C. Coil Assembly: UL 429 listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box.

2.11 REFRIGERANT EXPANSION VALVES

A. Manufacturers:
1. **Alco Controls Div, Emerson Electric Co.**
2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Angle or Straight Through Type: ARI 750; design suitable for refrigerant, brass body, internal or external equalizer.

C. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and oversized at part load.

2.12 ELECTRONIC EXPANSION VALVES

A. Manufacturers:
1. **Alco Controls Div, Emerson Electric Co.**
2. **Parker Hannifin Corp., Refrig. & Air Cond. Div.**
3. **Sporlan Valve Division / Parker Hannifin Corporation.**

B. Valve:
1. Brass bodies with flared or solder connection, needle valve with floating needle and machined seat, stepper motor drive.
2. Capacity: Nominal as shown on drawings.

C. Evaporation Control System:
1. Electronic microprocessor based unit in enclosed case, proportional integral control with adaptive superheat, maximum operating pressure function, pre-selection allowance for electrical defrost and hot gas bypass.

D. Refrigeration System Control: Electronic microprocessor based unit in enclosed case, with proportional integral control of valve, on/off thermostat, air temperature alarm (high and low), solenoid valve control, liquid injection adaptive superheat control, maximum operating pressure function, night setback thermostat, timer for defrost control.

2.13 REFRIGERANT RECEIVERS

A. Internal Diameter 6 inch and Smaller: ARI 495, UL listed, steel, brazed; 400 psig maximum pressure rating, with taps for inlet, outlet, and pressure relief valve.

B. Internal Diameter 6 inch and Larger: ARI 495, welded steel, tested and stamped in accordance with ASME Section VIII; 400 psig with taps for liquid inlet and outlet valves, pressure relief valve, and magnetic liquid level indicator.

PART 3 - EXECUTION

3.1 INSTALLATION - INSERTS

A. Provide inserts for placement in concrete forms.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger or casting anchor, or anchor inserts.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

3.2 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

B. Place hangers within 12 inches of each horizontal elbow.

C. Install hangers to allow 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

D. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.

E. Where installing several pipes in parallel and at same elevation, provide multiple pipe hangers or trapeze hangers.

F. Prime coat exposed steel hangers and supports in accordance with specifications herein. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

3.3 INSTALLATION - ABOVE GROUND PIPING SYSTEMS

A. Route piping parallel to building structure and maintain gradient.

B. Install piping to conserve building space, and not interfere with use of space.

C. Group piping whenever practical at common elevations.

D. Provide sleeve for pipe passing through partitions, walls and floors.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide access where valves and fittings are not exposed.

G. Arrange refrigerant piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow or manufactured recommendations.

H. Flood refrigerant piping system with nitrogen when brazing.

I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

J. Prime unfinished pipe, fittings, supports, and accessories, ready for finish painting.

K. Install valves with stems upright or horizontal, not inverted.

L. Insulate piping and equipment per these specifications.

M. Provide replaceable cartridge filter-dryers, with isolation valves and bypass with valve.

N. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

O. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

P. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

Q. Provide electrical connection to solenoid valves.

R. Fully charge completed system with refrigerant after testing.

S. Follow ASHRAE 15 procedures for charging and purging of systems and for disposal of refrigerant.

T. Install insulation as required.

3.4 INSTALLATION - REFRIGERANT SPECIALTIES

A. Refrigerant Liquid Indicators:

1. Install line size liquid indicators in main liquid line downstream of condenser.
2. When receiver is provided, install line size liquid indicators in liquid line downstream of receiver.
3. Install line size liquid indicators downstream of liquid solenoid valves.

B. Refrigerant Valves:

1. Install service valves on compressor suction and discharge.
2. Install gage taps at compressor inlet and outlet.
3. Install gage taps at hot gas bypass regulators, inlet and outlet.
4. Install check valves on compressor discharge.
5. Install check valves on condenser liquid lines on multiple condenser systems.
6. Install refrigerant charging valve in liquid line between receiver shut-off valve and expansion valve.

C. Strainers:

1. Install line size strainer upstream of each automatic valve.
2. Where multiple expansion valves with integral strainers are used, install single main liquid-line strainer.
3. On steel piping systems, install strainer in suction line.
4. Install shut-off valves on each side of strainer.

D. Install pressure relief valves on ASME receivers. Install relief valve discharge piping to terminate outdoors.

E. Filter-Dryers:

1. Install permanent filter-dryers in low temperature systems.
2. Install permanent filter-dryer in systems containing hermetic compressors.
3. Install replaceable cartridge filter-dryer vertically in liquid line adjacent to receivers.
4. Install replaceable cartridge filter-dryer upstream of each solenoid valve.

F. Solenoid Valves:

1. Install in liquid line of systems operating with single pump-out or pump-down compressor control.
2. Install in liquid line of single or multiple evaporator systems.
3. Install in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into suction line when system shuts down.

3.5 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ASME B31.5.

B. Pressure test refrigeration system with dry nitrogen to 200 psig.

C. Repair leaks.

D. Retest until no leaks are detected.

END OF SECTION 23 23 00

SECTION 23 25 00 - HVAC WATER TREATMENT

PART 1 -GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. HVAC water-treatment systems.
2. Chemical treatment test equipment.
3. HVAC water-treatment chemicals.

1.2 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available, HVAC system equipment material characteristics and functional performance characteristics.

C. Provide temporary water treatment for chilled, hot and condenser water until facility has final connections.

D. After connection to the Central Utilities Plant direct connected systems (chilled water and low temperature hot water), those systems will be treated from the Central Plant. Provide ongoing annual water treatment for the hot water heating system for one year. Treatment shall consist of monthly site visits with analysis of water conditions and adjustment of chemical treatment to maintain specified levels. In glycol systems, glycol concentration, inhibitors and reserve alkalinity, as recommended by the glycol manufacturer.

E. Closed hydronic systems, including low temperature, hot-water heating, chilled water and glycol cooling and/or heating, shall have the following water qualities:

1. pH: Maintain a value within 8.8 to 9.5.
2. Turbidity: Maintain a value less than 15 NTU.
3. Boron: Maintain a value within 100 to 200 ppm. (Glycol system) and less than 10 ppm for the closed hydronic system.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. TDS: Maintain a maximum value of 3000 ppm.
6. Ammonia: Maintain a maximum value of 5 ppm.
7. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
8. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.

c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.

d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.

e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

9. Treatment:

a. Low temperature hot water, closed cooling and chilled water - Mixture of sodium nitrite, borax and molybdate with other copper alloy inhibitor. For the chilled water a non-nitrite program of phosphate, polymer borate and copper alloy inhibitors: non-oxidizing, non-cationic biocide.

b. Glycol low temperature – Ethylene glycol with buffered phosphate based corrosion inhibitor with copper alloy inhibitor in deionized water, if water chloride levels are 750 ppm and contains hard water ions.

F. Open hydronic systems, including condenser water, shall have the following water qualities:

1. pH: Maintain a value within 7.0 to 9.0.

2. Langelier Saturation Index: Maintain a maximum value of +2.5 ppm.

3. Soluble Copper: Maintain a maximum value of 0.20 ppm.

4. Conductivity: Maintain a minimum value of 2400 uhmos. The goal of the plant is to run the highest conductivity possible for water conservation.

5. Ammonia: Maintain a maximum value of 20 ppm.

6. Free "OH" Alkalinity: Maintain a maximum value of 0 ppm

7. Silica: Maintain a maximum value of 125 ppm

8. Microbiological Limits:

a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.

b. Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.

c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.

d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.

e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

9. Polymer Testable: Maintain a minimum value within 10 to 40.

10. Treatment: organic phosphonate and polymeric dispersant with copper alloy inhibitor, or other chromate- free treatment in liquid form; suitable for pumping from containers directly to water system.

a. Alternate two biocides, one oxidizer and one non-oxidizer; increase dosage when significant amount of algae or slime are detected after system operations.

11. Bleed off:

a. Automatic control by condenser water conductivity and water meter signals.

b. To maintain maximum chloride concentration at the maximum level possible based on the incoming water quality up to 7 times concentration of make-up water to minimize corrosion and scale formation.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:

1. Water meters.
2. Inhibitor injection timers.
3. pH controllers.
4. TDS controllers.
5. Chemical solution tanks.
6. Injection pumps.
7. Chemical test equipment.
8. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.

1. Record actual locations of equipment and piping, including sampling points and locations of chemical injectors.
2. Wiring Diagrams: Power and control wiring.

C. Field quality-control test reports to indicate inhibitor levels, pH, conductivity, equipment conditions, chemical inventory and water usage data.

D. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

E. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
2. Water Analysis: Illustrate water quality available at Project site.
3. Certification of compliance: Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposal disposal.

1.4 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider with certified water technologists, capable of analyzing water qualities, installing water-treatment equipment.

1.5 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for

cooling, chilled-water piping, heating, hot-water piping, condenser-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Initial makeup and (and subsequent analysis of water quality changes) system water analysis with HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with disinfectant detergents, and initially fill systems with required chemical treatment prior to operation.
3. Minimum 4 hours of on-site training of plant engineers to use water treatment equipment, to handle and administer treatment chemicals.
4. Weekly field service and consultation.
5. Customer report charts and log sheets.
6. Laboratory technical analysis.
7. Analyses and reports of all chemical items concerning safety and compliance with government regulations.
8. Summary review reports with graphs every six months.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following airport wide water treatment vendor:

1. Nalco Company / An Ecolab Company

2.2 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Inhibitor Injection Timers:

1. Microprocessor-based controller with LCD display in NEMA 4X, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at BAS.
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
8. Timer mode includes: Choice of percent timer, water meter timer, limit timer and 28-day programmable timer.

B. pH Integral Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at BAS.
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low pH alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

C. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene or higher quality stainless steel, with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: Maintain inventory sufficient to meet the system demands

D. Chemical Solution Injection Pumps:

1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor.

E. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

F. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece, stainless steel.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).
5. Materials of construction: Stainless steel 316, Nickel alloy, Carpenter 20, PVC.

G. Fail-Safes and Alarms

1. Corrosion safety interlock: Alarm indication, lock-out all chemical feed, open bleed-off valve to flush corrosive water from system.
2. PH interlock: Alarm indication, lock-out all chemical feed, open bleed-off valve to reduce total dissolved solids in cooling tower water.
3. Flow interlock (on loss of flow): Alarm indication, lock-out all control outputs and chemical feeds.

H. Low Level Alarms

1. Low level alarm system to monitor chemical solution level in inhibitor, pH modifier (acid or alkali), biocide, and dispersant drums.
2. Alarm probes, suitable current system capacity and connected with flexible cable.
3. Signal output suitable for remote alarm function in addition to local alarm.

2.3 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, phosphate, silica and hardness; oxygen scavenger and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.

B. Sample Cooler:

1. Shell: Cooling water.
   a. Material: ASTM A 666, Type 304 stainless steel.
   b. Pressure Rating: Minimum 250 psig (1725 kPa).
   c. Temperature Rating: Minimum 450 deg F (232 deg C).
2. Capacities and Characteristics:
   a. Tube: Sample.
      1) Flow Rate: 0.25 gpm (0.016 L/s).
      2) Entering Temperature: 400 deg F (204 deg C).
      3) Leaving Temperature: 88 deg F (31 deg C).
      4) Pressure Loss: 6.5 psig (44.8 kPa).
   b. Shell: Cooling water.
      1) Flow Rate: 3 gpm (0.19 L/s).
      2) Entering Temperature: 70 deg F (21 deg C).
      3) Pressure Loss: 1.0 psig (6.89 kPa).

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons in accordance with ASTM D2688. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two-station rack for closed-loop systems.

2. Two station rack for open systems.

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified herein.

2.5 GLYCOL SYSTEMS – HEATING AND COOLING

A. Use "Environmentally Friendly" glycol.

B. Coordinate compatibility of glycol with materials used in piping, valves, equipment and accessories.

C. Provide glycol feed system.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Install automatic chemical-feed equipment for condenser water and include the following:

1. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection for the heating and chilled water loops only. Pumps for the cooling towers and steam boilers shall operate base on the actual chemistry of the water.

2. Install test equipment and provide test-kit to LAWA. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.

3. Install TDS controller with sensor and bleed valves.
    a. Bleed valves shall cycle to maintain maximum TDS concentration.
4. Install pH, conductivity and Oxidation-Reduction Potential (ORP) sensors with integral controller, injection pumps and solution tanks.
    a. Injector pumps shall operate to maintain required pH and ORP.
5. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
    a. Injection pumps shall operate to feed biocide on an alternating basis.

G. Install corrosion resistant drip pan, a minimum of 3 in (75 mm) high, under tanks and pumps. Intent is to contain minor leaks.

3.3 CONNECTIONS

A. Install piping adjacent to equipment to allow service and maintenance.

B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with 6 inch long brass nipple for the pipes 1 ½ inch and smaller and dielectric flange for the pipes 2 inch and larger. Dielectric flanges are allowed in the pump and fan rooms only.

C. Install unions, shutoff valves on HVAC water-treatment equipment inlet and outlet.

D. Provide backflow preventers for temporary water, make-up water or flushing.

E. Provide appropriate equipment grounding.

F. Provide backflow preventers on domestic water system connections.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.
    1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Install and retrieve corrosion coupons every 90 days to generate quarterly reports on corrosion rates of steel and copper with photographic images of the coupons.

C. Tests and Inspections:
    1. Inspect field-assembled components and equipment installation, including piping and electrical connections.

2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified herein. Submit written reports of water analysis advising LAWA of changes necessary.

F. Comply with ASTM D 3370 and with the following standards:
1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.
5. Chloride: ASTM D4458
6. Copper: ASTM D1688
7. pH: ASTM D5464

3.5 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Engage a factory-authorized service representative to train LAWA’s Maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

C. Provide a minimum of 12 hours (3 shifts total) of classroom and hands on training to LAWA Maintenance personnel on handling and testing of treatment chemicals with "how-to-use" video that details exact operating procedures of equipment.

3.6 FINAL CONNECTION TO SITE UTILITIES

A. Do not circulate any water from the site chilled and high temperature hot water mains until the CUP water treatment contractor has certified the water quality of both sides of the site utility isolation valves.

B. After connection to plant utilities are achieved remove temporary bypass pipes and cap.

END OF SECTION 23 25 00

SECTION 23 31 13 - HVAC DUCTS AND CASINGS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Flush flat seam rectangular ducts and fittings.
4. Sheet metal materials.
5. Flexible Ducts.
6. Insulated flexible ducts.
7. Casings.
8. Duct Sealants and Gaskets.
9. Hangers and Supports.
10. Seismic Restraint Devices.

1.2 REFERENCES

A. ASTM International: Provide appropriate references.

B. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

C. Sheet Metal and Air Conditioning Contractors:

1. SMACNA - HVAC Air Duct Leakage Test Manual.
2. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

D. Underwriters Laboratories Inc.:

1. UL 181 - Factory-Made Air Ducts and Connectors.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with the latest edition of the City of Los Angeles Mechanical Code and SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" section of this specification.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in the Code and LAWA Airport Structural Design Standards. Subject to compliance, SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" may be followed.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Sealants and gaskets.
2. Other factory made items specified herein.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
3. Elevation of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Penetrations through fire-rated and other partitions.
7. Equipment installation based on equipment being used on Project, including curbs and bases.
8. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.

C. Delegated-Design Submittal:

1. Factory- and shop-fabricated ducts and fittings min. scale 1/4".
2. Reinforcement and spacing.
3. Seam and joint construction.
4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
5. Sheet metal thicknesses.
6. Joint and seam construction and sealing.
7. Reinforcement details and spacing.
8. Materials, fabrication, assembly, and spacing of hangers and supports.
9. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

E. Welding certificates.

F. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. McGill AirFlow LLC.
    b. SEMCO Incorporated.
    c. Spiral Manufacturing Co., Inc.

2.3 FLUSH FLAT SEAM RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class, except use sheet metal 2 gauge numbers heavier than required for classification with normal standing seam construction.

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with the City of Los Angeles Mechanical Code and SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: minimum G60 or minimum G90 for exposed ductwork.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 FLEXIBLE DUCTS

A. Manufacturers:

1. **Flexmaster USA, Inc.**
2. **Hart & Cooley Inc.**
3. **Casco**

B. Product Description: Two ply vinyl film supported by helical wound spring steel wire.

1. Pressure Rating: 1.5 inches water gauge (WG) positive and 0.5 inches WG negative.
2. Maximum Velocity: 4000 fpm.
3. Temperature Range: -10 degrees F to 160 degrees F.

2.6 INSULATED FLEXIBLE DUCTS

A. Manufacturers:
   1. **Flexmaster USA, Inc.**
   2. **Hart & Cooley Inc.**
   3. **Casco**

B. Product Description: Two ply vinyl film supported by helical wound spring steel wire; fiberglass insulation; polyethylene vapor barrier film.
   1. Pressure Rating: 1.5 inches WG positive and 0.5 inches WG negative.
   2. Maximum Velocity: 4000 fpm.
   3. Temperature Range: -10 degrees F to 160 degrees F.
   4. Thermal Resistance: Comply with ASHRAE 90.1-2013 or most recent version.

2.7 CASINGS

A. Fabricate casings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and construct for required operating pressures.

B. Reinforce access door frames with steel angles tied to horizontal and vertical plenum supporting angles. Furnish hinged access doors where indicated or required for access to equipment for cleaning and inspection. Furnish clear wire glass observation ports, minimum 6 x 6 inch size.

2.8 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   3. Shore A Hardness: Minimum 20.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch WG, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer, 1/8 inch thick of width to match angle connection.

2.9 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Duct Attachments: All duct attachments and anchors to structure shall be designed and selected to meet Code requirements and LAWA Airport Structural Design Standards.

E. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Galvanized-steel shapes and plates with protection against dissimilar metals.
3. Supports for Aluminum Ducts: Aluminum or galvanized-steel shapes and plates with protection against dissimilar metals.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Install round ducts in maximum practical lengths.

B. Install ducts with fewest possible joints.

C. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

D. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

G. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

H. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

I. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

J. Ducts that traverse smoke zones shall be fabricated of sheet metal gauges conforming to NFPA 90A.

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

L. Duct Openings:

1. Provide openings in ducts where required to accommodate thermometers, smoke detectors, control devices, sensors, and devices. Install same though airtight rubber grommets.
2. Provide pilot tube openings where required for testing of systems. Each opening shall be complete with a metal cap, with a spring device or screw to ensure against air leakage.
3. At openings in insulated ducts, install insulation material inside metal ring.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction, at junctions and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as

indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 INSTALLATION OF DUCTS OUTDOORS

A. Ducts shall be made completely watertight.

B. Construct ducts as follows to assure water run-off.

1. Arrange standing seams so as not to act as dams.
2. Erect ducts with longitudinal seams at bottom of duct.
3. Slope entire top of duct down towards side.
4. Provide vertical struts within duct to bow tap panels of duct into convex shape.
5. Erect ducts with mastic sealant within sheet metal joints.

3.5 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch WG and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch WG: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes2-Inch WG and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch WG: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection. Extend strap supports down both sides of ducts and turn under bottom at least 1 inch. Secure hanger to sides and bottom of ducts with sheet metal screws.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Avoid penetrations of ducts. Provide airtight rubber grommets at unavoidable penetrations of hanger rods.

3.7 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the LAWA if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and hot-dip galvanized or stainless-steel anchors for applications exposed to weather.

3.8 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.9 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

2. Test the following systems:
    a. Ducts with a Pressure Class Higher Than 3-Inch WG: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 DUCT CLEANING

A. Clean new ductwork that fails the cleanliness test before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
2. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
3. Coils and related components.
4. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
5. Supply-air ducts, dampers, actuators, and turning vanes.
6. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.12 START UP

A. Air Balance: Comply with requirements in Section "Testing, Adjusting, and Balancing for HVAC."

B. Comply with Commissioning requirements.

END OF SECTION 23 31 13

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Back-draft dampers.
2. Backdraft and pressure relief dampers.
3. Barometric relief dampers.
4. Combination fire/smoke dampers.
5. Duct access doors.
6. Static fire dampers.
7. Ceiling fire dampers.
8. Volume control dampers.
9. Flexible duct connections.
10. Dial thermometers.
11. Static pressure gauges.
12. Motorized control dampers.
13. Louvers.
14. Air flow measuring stations.
15. Turning vanes.

1.2 REFERENCES

A. Air Movement and Control Association International, Inc.:

1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

B. ASTM International:

1. ASTM E1 - Standard Specification for ASTM Thermometers.

C. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
3. NFPA 92A - Recommended Practice for Smoke-Control Systems.

D. Sheet Metal and Air Conditioning Contractors' National Association:

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

E. Underwriters Laboratories Inc.:

1. UL 555 - Standard for Safety for Fire Dampers.
2. UL 555C - Standard for Safety for Ceiling Dampers.
3. UL 555S - Standard for Safety for Smoke Dampers.

1.3 SUBMITTALS

A. Product Data: Submit data for shop fabricated assemblies and hardware used.

B. Product Data: Submit for the following. Include where applicable electrical characteristics and connection requirements.

1. Fire dampers including locations and ratings.
2. Combination Fire-Smoke dampers including locations and ratings.
3. Backdraft dampers.
4. Flexible duct connections.
5. Volume control dampers.
6. Duct access doors.
7. Duct test holes.

C. Product Data: For fire dampers and combination fire/smoke dampers submit the following:

1. Include UL ratings, dynamic ratings, leakage, pressure drop and maximum pressure data.
2. Indicate materials, construction, dimensions, and installation details.
3. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

D. Manufacturer's Installation Instructions: Submit for Fire and Combination Smoke/Fire Dampers.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

PART 2 - PRODUCTS

2.1 BACK-DRAFT DAMPERS

A. Manufacturers:

1. **Air Balance, Inc.**
2. **Ruskin.**
3. **Pottorf.**

B. Product Description: Multi-Blade, back-draft dampers: Parallel-action, gravity-balanced, Galvanized 16 gauge thick steel, or extruded aluminum. Blades, maximum 6 inch width, with felt or flexible vinyl sealed edges. Blades linked together in rattle-free manner with 90-degree stop, steel ball bearings, and plated steel pivot pin. Furnish dampers with adjustment device to permit setting for varying differential static pressure.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. **Air Balance Inc**
2. **Ruskin**
3. **Pottorf.**

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm (10 m/s).

D. Maximum System Pressure: 2-inch WG (0.5 kPa).

E. Frame: 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Stainless steel.
2. Diameter: 0.20 inch (5 mm).

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.

a. Sleeve Thickness: 20-gauge (1.0-mm) minimum.

b. Sleeve Length: 6 inches (152 mm) minimum.

6. Screen Mounting: Rear mounted.

7. Screen Material: Aluminum.

8. Screen Type: Insect.

9. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. **Air Balance Inc.**
2. **Ruskin.**
3. **Pottorf.**

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 2000 fpm (10 m/s).

D. Maximum System Pressure: 2-inch WG (0.5 kPa).

E. Frame: 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners and mounting flange.

F. Blades:

1. Multiple, 0.050-inch- (1.2-mm-) thick aluminum sheet.
2. Maximum Width: 6 inches (150 mm).
3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Galvanized steel.

I. Tie Bars and Brackets:

1. Material: Aluminum.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Stainless steel.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. **Air Balance, Inc.**
2. **Ruskin.**
3. **Pottorf.**

B. Fire Resistance: 1-1/2 hours or 3 hoursConform to UL 555.

C. Leakage Rating: Class I, maximum of 8 cfm at 4 inches WG differential pressure.

D. Damper Temperature Rating: 250 degrees F.

E. Frame: 16 gauge, galvanized steel.

F. Blades:

1. Style: Airfoil-shaped, single piece, double skin.
2. Action: Opposed.
3. Orientation: Horizontal.
4. Material: Minimum 14 gauge equivalent thickness, galvanized steel.
5. Width: Maximum 6 inches.

G. Bearings: Stainless steel pressed into frame.

H. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.

I. Linkage: Concealed in frame.

J. Release Device: Close in controlled manner and allow damper to be automatically reset.

K. Actuator:

1. Type: Electric 120 volt, 60 hertz, two-position, fail close or Electric 24 volt, 60 hertz, two-position, fail close as shown on drawings.
2. Mounting: External or Internal.

L. Fusible Link Release Temperature: 165 degrees F.

M. Finish: Mill galvanized.

N. Factory installed sleeve and mounting angles. Furnish silicone caulk factory applied to sleeve at damper frame to comply with leakage rating requirements.

2.5 DUCT ACCESS DOORS

A. Manufacturers:

1. **American Warming and Ventilating.**
2. **Pottorf.**
3. **McGill.**

B. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, furnish minimum 1 inch thick insulation with sheet metal cover.

1. Less than 12 inches square, secure with sash locks.
2. Up to 18 inches Square: Furnish two hinges and two sash locks.
3. Up to 24 x 48 inches: Three hinges and two compression latches.
4. Larger Sizes: Furnish additional hinge.
5. Access panels with sheet metal screw fasteners are not acceptable.

2.6 FIRE DAMPERS

A. Manufacturers:

1. **Air Balance, Inc.**
2. **Ruskin.**
3. **Pottorf**.

B. Fire Rating: UL 555 classified, curtain type, and labeled as a 1-1/2 or 3 hour static fire damper.

C. Air Flow Rating: UL approved for dual directional air flow.

D. Integral Sleeve Frame: Minimum 20 gauge by 12 inches roll formed, galvanized steel.

1. Factory Sealant: Apply to dampers in HVAC systems with pressures to maximum 4 inches WG.

E. Blades:

1. Style: Curtain type, in airstream.
2. Action: Spring or gravity closure upon fusible link release.
3. Orientation: Horizontal.
4. Material: Minimum 24 gauge roll formed, galvanized steel.

F. Closure Springs: Type 301 stainless steel, constant force type, if required.

G. Temperature Release Device:

1. Fusible link, 165 degrees F.
2. Mounting: Vertical or Horizontal as shown on the drawings.

H. Finish: Mill galvanized.

I. Picture Frame Mounting Angles:

1. One-piece, roll formed retaining angles as detailed.
2. Factory matched and shipped attached to damper.

2.7 CEILING FIRE DAMPERS

A. Manufacturers:

1. **Air Balance, Inc.**
2. **Ruskin.**
3. **Pottorf.**

B. Fire Rating: UL 555C classified and labeled as a 1-1/2 hour ceiling damper.

C. Air Flow Rating: UL approved for dual directional air flow.

D. Frame: Galvanized steel with roll formed ridge for blade stop.

E. Blades:

1. Style: Two-piece, single-thickness with blade insulation, hinged in center, and held open with fusible link.
2. Action: Butterfly.
3. Orientation: Horizontal.
4. Material: Minimum 20 gauge galvanized steel.

F. Hinge: Spring stainless steel, mechanically attached to blades.

G. Mounting: Horizontal.

H. Temperature Release Device: Fusible link, 165 degrees F.

I. Finish: Mill galvanized.

J. Performance Data:

1. Pressure Drop: Maximum 0.1 inches w.g. at 500 fpm across 18 x 18 inch damper.

K. Fusible Volume Adjust: UL classified.

2.8 VOLUME CONTROL DAMPERS

A. Manufacturers:

1. **Air Balance, Inc.**
2. **Ruskin.**
3. **Pottorf.**

B. Splitter Dampers:

1. Material: Same gauge as duct to 24 inches size in both dimensions, and two gauges heavier for sizes over 24 inches.
2. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
3. Operator: Minimum 1/4 inch diameter rod in self-aligning, universal joint action, flanged bushing with set screw.
4. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

C. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized frame channel with suitable hardware.

D. Quadrants:

1. Furnish locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on standoff mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches furnish regulator at both ends.

2.9 FLEXIBLE DUCT CONNECTIONS

A. Manufacturers:

1. **Duro Dyne Inc.**
2. **Ventfabrics.**
3. **Ward Industries**

B. Connector: Fabric crimped into metal edging strip.

1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric conforming to NFPA 90A, minimum density 30 oz per sq yd.
2. Net Fabric Width: Approximately 3 inches wide.
3. Metal: 3 inch wide, 24 gauge galvanized steel.

C. Leaded Vinyl Sheet: Minimum 0.55 inch thick, 0.87 lbs. per sq ft, 10 dB attenuation in the 10 to 10,000 Hz range.

2.10 DIAL THERMOMETERS

A. Manufacturers:

1. **Ashcroft.**
2. **Trerice.**
3. **Watts.**

B. Thermometer: ASTM E1, stainless steel case, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.

1. Size: 3 inch diameter dial.
2. Lens: Clear Lexan.
3. Accuracy: 1 percent.
4. Calibration: Degrees F.

2.11 STATIC PRESSURE GAUGES

A. Manufacturers:

1. **Ashcroft.**
2. **Trerice.**
3. **Watts.**

B. Dial Gauges: 3-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front calibration adjustment, 2 percent of full scale accuracy.

C. Inclined Manometer: Plastic with red liquid on white background with black figures, front calibration adjustment, 3 percent of full scale accuracy.

D. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

2.12 MOTORIZED CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by BAS vendor or one of the following:

1. **Air Balance Inc.; a division of Mestek, Inc.**
2. **Ruskin Company.**
3. **Pottorf.**

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Hat shaped.
2. Stainless-steel channels, 0.064 inch (1.62 mm) thick.
3. Mitered and welded corners.

D. Blades:

1. Multiple blades with maximum blade width of 8 inches (200 mm).
2. Opposed-blade design.
3. Stainless steel.

4. 0.064 inch (1.62 mm) thick.
5. Blade Edging: Closed-cell neoprene edging.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- (13-mm-) diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).

F. Bearings:
1. Stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch WG (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.
4. Damper Motors: Modulating action.

2.13 LOUVERS

A. Connect to louvers furnished under General Construction work.

2.14 AIR FLOW MEASURING STATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. **Ruskin, IAQ Measuring Damper, Model AML3.**
2. **Air Monitor Corp.**
3. **Wetmaster Co**.

B. Description: Factory fabricated unit with casing, velocity traverse section and sensors, companion volume meter, and interconnection to volume meter. Air monitoring station must be accurate within 5% between 350 and 400 fpm free area velocity. Air flow resistance not to exceed 0.04” WG at 1000 fpm face velocity.

C. Casing: 0.064 inch (1.62 mm) thick welded galvanized sheet steel, with flanged ends to match connecting ductwork.

D. Velocity Traverse Section:
1. Copper static pressure sensors.
2. Copper total pressure sensing manifolds and control averaging manifold.
3. Operation: Equalizing and integrating all sensor measurements into one total pressure and one static pressure metering port.
4. Sensors positioned on equal-area traverse principle.
5. Aluminum honeycomb air straightener.

E. Volume Meter:

1. Dry dial and diaphragm-actuated type.
2. Calibrated in CFM (cu cm/sec) and FPM (m/s).
3. Provided with mounting bracket.

F. Install nameplate for each station to indicate:

1. Unit size and unit designation.
2. Design air quantity.
3. Design air flow.
4. Design air velocity.

2.15 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. **Ductmate Industries, Inc.**
2. **Duro Dyne Inc.**
3. **Metalaire.**

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized steel, aluminum or stainless steel sheet, to match duct material; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

PART 3 - EXECUTION

3.1 INSTALLATION.

A. Install back-draft dampers on exhaust fans or exhaust ducts nearest to outside.

B. Access Doors:

1. Install access doors at the following locations:

a. On both sides of duct coils.

b. Upstream and downstream from duct filters.

c. At outdoor-air intakes and mixed-air plenums.

d. At drain pans and seals.

e. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.

f. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

g. At each change in direction and at maximum 50-foot spacing.

h. Upstream and downstream from turning vanes.

i. Upstream or downstream from duct silencers.

j. Control devices requiring inspection, including smoke detection heads.

k. At fan bearings enclosed in ducts.

l. Inlet side of each single width centrifugal fan.

m. Install at locations for cleaning kitchen exhaust ductwork in accordance with NFPA 96.

2. Install access doors with swing against duct static pressure.

3. Access Door Sizes:

a. One-Hand or Inspection Access: 8 by 5 inches.

b. Two-Hand Access: 12 by 6 inches.

c. Head and Hand Access: 18 by 12 inches.

d. Head and Shoulders Access: 21 by 14 inches.

e. Body Access: 25 by 14 inches.

f. Body plus Ladder Access: 25 by 17 inches.

4. Label access doors according to Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

5. Mark access doors for fire and smoke dampers on outside surface, with minimum 1/2 inch high letters reading: FIRE/SMOKE DAMPER, SMOKE DAMPER, OR FIRE DAMPER.

C. Flexible Connectors.

1. Install flexible connectors at duct connections to equipment, at building expansion joints, at connections between ducts of dissimilar metals and at penetrations of mechanical equipment room walls.

2. Install flexible connections with 2 inches slack in fabric and minimum movement of 1 inch.

3. For fans developing static pressures of 5-inch WG and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

D. Flexible Ducts

1. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
2. Connect diffusers or light troffer boots to ducts with maximum 18-inch lengths of flexible duct clamped or strapped in place.
3. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws. Attach to supply air duct with low entrance lass, bellmouth type connector at air inlet end.

E. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

F. Install wire mesh screen grilles at return air ducts in hung ceilings and in other places where indicated. Bolt grilles to flanged connections or ducts at terminations.

G. Install louvers in building construction at locations where indicated. Coordinate mounting details with particular building construction and/or window framing details. Install blank-off panels at unused portions of louvers; secured with bolts and/or screws.

H. Air Flow Measuring Stations

1. Install air flow measuring stations where indicated, or as directed by engineer.
2. Install all interconnecting tubing between measuring station, companion meter and control systems, in accordance with the manufacturer's printed instructions.

I. Install temporary duct test holes and required for testing and balancing purposes. Cut or drill in ducts. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

J. Install fire dampers and combination fire and smoke dampers at required locations. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

1. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92A.
2. Install dampers square and free from racking with blades running horizontally.
3. Do not compress or stretch damper frame into duct or opening.
4. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jack shaft.
5. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

K. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

L. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts and as indicated. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install volume dampers at the following locations:
    a. At all splits, except grease exhaust ducts.
    b. In ducts serving single supply, return and exhaust outlets.
    c. In open return ducts above ceiling.
    d. In ducts connecting to a common plenum.
    e. Where required for balancing.
2. Install remote damper operators for volume dampers above ceilings which are non-accessible or without access panels.
3. Install steel volume dampers in steel ducts.
4. Install aluminum volume dampers in aluminum ducts.
5. Do not install volume dampers in grease ducts.

END OF SECTION 23 33 00

SECTION 23 34 00 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Centrifugal fans.
   2. Propeller fans.
   3. Downblast centrifugal roof fans.
   4. Upblast centrifugal roof fans.
   5. Ceiling fans.
   6. Inline ceiling fans.
   7. Duct blowers or cabinet fans.
   8. Centrifugal square inline fans.

1.2 REFERENCES

A. American Bearing Manufacturers Association:
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:
   1. AMCA 99 - Standards Handbook.
   2. AMCA 204 - Balance Quality and Vibration Levels for Fans.
   3. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
   4. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
   5. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

C. ASTM International:
   1. ASTM E1996 - Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.

D. National Electrical Manufacturers Association:
   1. NEMA MG 1 - Motors and Generators.
   2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. Underwriters Laboratories Inc.:
   1. UL 705 - Power Ventilators.

1.3 SUBMITTALS

A. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fan Corp.**
   3. **Loren Cook Fan Company**

B. Wheel and Inlet:
   1. Backward Inclined: Steel construction with smooth curved inlet flange, back plate, backward curved blades welded or riveted to flange and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
   2. Forward Curved: Galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; steel hub swaged to back plate and keyed to shaft with set screw.
   3. Airfoil Wheel: Steel construction with smooth curved inlet flange, back plate die formed hollow airfoil shaped blades continuously welded at tip flange, and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.

C. Housing:
   1. Steel, spot welded for AMCA 99 Class I and II fans, and continuously welded for Class III, braced, designed to minimize turbulence with spun inlet bell and shaped cut-off.
   2. Factory finish before assembly to manufacturer's standard.
   3. Fabricate plug fans without volute housing, in lined steel cabinet.

D. Bearings and Sleeves:
   1. Bearings: Pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-10 life at 50,000 hours roller bearings, ABMA 11, L-10 life at 120,000 hours.
   2. Shafts: Hot rolled steel, ground and polished, with key way, protectively coated with lubricating oil, and shaft guard.
   3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 hp and under, selected so required rpm is obtained with sheaves set at mid-position. Fixed sheave for 20 hp and

over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of motor.

2.2 PROPELLER FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fan Co.**
   3. **Loren Cook Company.**

2.3 DOWNBLAST CENTRIFUGAL ROOF FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fan Co.**
   3. **Loren Cook Company.**

2.4 UPBLAST CENTRIFUGAL ROOF FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fan Co.**
   3. **Loren Cook Company.**

B. Fan Unit: Upblast type. V-belt or direct drive, spun aluminum housing with grease tray; resilient mounted motor; aluminum wire bird screen; square base to suit roof curb with continuous curb gaskets.

C. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

D. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.

2.5 CEILING FANS AND INLINE CEILING FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fan Co.**
   3. **Loren Cook Company.**

B. Centrifugal Fan Unit: Direct driven with galvanized steel housing lined with 1/2 inch acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge opening, integral outlet duct collar. Discharge position convertible by moving interchangeable panels.

C. Disconnect Switch: Fan mounted toggle switch for thermal overload protected motor.

D. Motor: Open drip proof type with permanently lubricated sealed bearings and thermal overload protection.

2.6 DUCT BLOWER OR CABINET FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fan Corp.**
   3. **Loren Cook Company.**

B. Product Description: V-belt drive with galvanized steel housing lined with 1/2 or 1 inch acoustic glass fiber insulation as scheduled, removable side panel for access, inlet and outlet duct collar, gravity backdraft damper in discharge, horizontal hanging brackets.

C. Fan Wheel: Double width-double inlet backward inclined forward curved centrifugal type.

D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.7 CENTRIFUGAL SQUARE INLINE FANS

A. Manufacturers:
   1. **Twin City Fan Co.**
   2. **Greenheck Fna Corp.**
   3. **Loren Cook Company.**

B. Product Description: V-belt or Direct drive with galvanized steel housing lined with 1/2 or 1 inch acoustic glass fiber insulation, integral inlet cone, removable access doors on 3 sides, inlet and outlet duct collar, gravity backdraft damper in discharge, horizontal hanging brackets.

C. Fan Wheel: Backward inclined centrifugal type, aluminum construction.

D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

E. Motor and Drive Mounting: Out of air stream.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer’s instructions.

B. Install backdraft dampers where required by code.

C. Install safety screen where inlet or outlet is exposed.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain centrifugal fans.

C. Train LAWA Maintenance personnel to adjust, operate, and maintain centrifugal fans.

D. Provide minimum of 12 hours each (3 shifts) of classroom and hands on training to LAWA Maintenance personnel.

END OF SECTION 23 34 00

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Constant volume terminal units.
2. Variable volume terminal units.
3. Fan powered terminal units.

NOTE: Terminal Units shall be provided with electronic Direct Digital Controller with BACnet open protocol communications and electronic actuators for damper and reheat coil control valve.

1.2 REFERENCES

A. American Refrigeration Institute:

1. ARI 880 - Air Terminals.
2. ARI 885 - Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

B. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

D. Underwriters Laboratories Inc.:

1. UL 181 - Factory-Made Air Ducts and Connectors.

E. American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

1. ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality.

1.3 SUBMITTALS

A. Product Data: Submit data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings indicating airflow, static pressure, heating coil capacity and NC designation. Include electrical characteristics and connection requirements. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 inch to 4 inches WG.

B. Manufacturer's Installation Instructions: Submit support and hanging details, and service clearances required.

1.4 CLOSEOUT SUBMITTALS

A. Execution and Closeout Requirements:

B. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

1.5 WARRANTY

A. Minimum one-year warranty.

PART 2 – PRODUCTS

2.1 SINGLE DUCT CONSTANT AND VARIABLE VOLUME AIR TERMINAL UNITS

A. Manufacturers:
   1. **Anemostat.**
   2. **Price**
   3. **Titus.**

B. Product Description: Variable air volume terminal units for connection to central air systems, with electronic controls and hot water heating coils.

C. Identification: Furnish each air terminal unit with identification label and airflow indicator. Include unit nominal airflow, maximum factory-set airflow and minimum factory-set airflow and coil type.

D. Basic Assembly:
   1. Casings: Minimum 22 gauge galvanized steel.
   2. Lining: Minimum 3/4 inch thick neoprene or vinyl coated glass fiber insulation, 1.5 lb./cu ft density, meeting NFPA 90A requirements and UL 181 erosion requirements.
   3. Plenum Air Outlets: S slip-and-drive connections.

E. Basic Unit:
   1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
   2. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings; maximum damper leakage: 2 percent of design air flow at 3 inches inlet static pressure.

F. Attenuation Section: Line attenuation sections with 1 or 2 inches thick insulation.

G. Round Outlet: Discharge collar matching inlet size.

H. Hot Water Heating Coil:

1. Construction: 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
2. All coils shall be minimum 2-pass.

2.2 FAN POWERED VARIABLE VOLUME UNITS

A. Manufacturers:

1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Product Description: Variable air volume terminals for connection to central air systems with electronic controls and hot water heating coils.

C. Identification: Furnish each air terminal unit with identification label and airflow indicator. Include unit nominal airflow, maximum factory-set airflow and minimum factory-set airflow and coil type.

D. Basic Assembly:

1. Casings: Minimum 22 gauge galvanized steel.
2. Lining: Minimum 3/4 inch thick neoprene or vinyl coated glass fiber insulation, 1.5 lb./cu ft density, meeting NFPA 90A requirements and UL 181 erosion requirements.
3. Plenum Air Outlets: S-slip and drive connections.

E. Basic Unit:

1. Configuration: Air volume damper assembly and fan in series or parallel arrangement inside unit casing. Locate control components inside protective metal shroud.
2. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings; maximum damper leakage: 2 percent of design air flow at 3 inches inlet static pressure.

F. Fan Assembly:

1. Fan: Forward curved centrifugal type with direct drive permanent-split-capacitor type, thermally protected motor.
2. Speed Control: Infinitely adjustable with electric/pneumatic and electronic controls.
3. Isolation: Fan/motor assembly on rubber isolators.

G. Wiring:

1. Factory mount and wire controls. Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source.
2. Factory mount transformer for control voltage on electric and electronic control units. Furnish terminal strip in control box for field wiring of thermostat and power source.

3. Wiring Terminations: Wire fan and controls to terminal strip. Furnish terminal lugs to match branch-circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box.
4. Disconnect Switch: Factory mount disconnect switch.

H. Variable Air Volume and Constant Air Volume terminal air units shall be supplied with the factory installed BacNet controllers:

1. The terminals shall be equipped with pressure independent direct digital controls (DDC) supplied and mounted by the terminal unit manufacturer. The DDC controls shall be installed and commissioned by the controls contractor.
2. Controls shall be compatible with pneumatic inlet velocity sensor supplied be the terminal's manufacturer. The sensor shall be multi point center averaging type with four measuring ports parallel to the take of point of the sensor. Sensors with measuring ports in series are not acceptable. The sensor must provide a minimum differential pressure signal of 0.03 WG at the inlet velocity of 500 fpm.
3. Controls shall be factory set for unit size and the scheduled minimum and maximum flow rates. Controller shall be BACnet compliant and has to be listed and stamped by the BACnet Testing Laboratory.
4. Controls shall be supplied with a flush-mounted room temperature sensor that also serves as the commissioning interface to the terminal unit mounting controller.
5. The terminal air unit manufacturer shall provide Class II, 24 VAC transformer and disconnect switch. Actuator shall be direct connection shaft mount type without linkage. All controls shall be installed in approved NEMA1 sheet metal enclosure.
6. Manufacturers:
   a. **Titus**
   b. **Neptronic**
   c. **KMC Controls**

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install ceiling access doors or locate units above easily removable ceiling components.

B. Support units individually from structure. Do not support from adjacent ductwork.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Engage a factory-authorized service representative to train LAWA Maintenance personnel to adjust, operate and maintain Air Terminal Units.

C. Training shall include minimum of 8 LAWA personnel for 24 hours, 8 hours shall be classroom training per person and 16 hours shall be hands-on training per person.

END OF SECTION 23 36 00

SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diffusers.
2. Registers
3. Grilles.

PART 2 - PRODUCTS

2.1 ROUND CEILING DIFFUSERS

A. Manufacturers:

1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Product Description: Type: Round, adjustable pattern, stamped or spun, multi-core diffuser to discharge air in 360 degree pattern, with sector baffles where indicated. Diffuser collar not more than 1 inch above ceiling. In plaster ceilings, furnish plaster ring and ceiling plaque.

C. Fabrication: Steel or aluminum with baked enamel off-white finish.

2.2 RECTANGULAR CEILING DIFFUSERS

A. Manufacturers:

1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type: Square and rectangular, adjustable pattern, multi-louvered diffuser.

C. Frame: To match the architectural surface.

D. Fabrication: Steel or Aluminum with baked enamel off-white finish.

2.3 PERFORATED FACE CEILING DIFFUSERS

A. Manufacturers:

1. **Anemostat.**
2. **Price.**

3. **Titus**.

B. Type: Perforated face with fully adjustable pattern and removable face.

C. Frame: To match architectural surface.

D. Fabrication: Steel or aluminum with steel frame and baked enamel off-white finish.

2.4 CEILING SLOT DIFFUSERS (LINEAR)

A. Manufacturers:
1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type: Continuous with size and number of slots and adjustable vanes for left, right or vertical discharge.

C. Fabrication: Aluminum extrusions or Steel with factory finish and color to be selected by architect.

D. Frame: To match architectural surface.

2.5 CEILING SUPPLY REGISTERS/GRILLES

A. Manufacturers:
1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, two-way deflection.

C. Frame: 1 inch margin with countersunk screw mounting and gasket.

D. Fabrication: Steel or aluminum extrusions with factory off-white enamel finish unless noted otherwise.

E. Damper: Integral, gang-operated, opposed-blade type with removable key operator, operable from face.

2.6 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:
1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees.

C. Frame: 1 inch margin with countersunk screw mounting.

D. Fabrication: Steel with 20 gauge minimum frames and 22 gauge minimum blades, steel and aluminum with 20 gauge minimum frame, or aluminum extrusions, with factory off-white baked enamel finish.

E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

2.7 CEILING GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:
1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type: Fixed grilles of 1/2 x 1/2 x 1 inch louvers.

C. Fabrication: Steel or aluminum with off-white finish.

D. Frame: 1 inch margin with countersunk screw mounting. Channel lay-in frame for suspended grid ceilings.

2.8 CEILING LINEAR EXHAUST AND RETURN GRILLES

A. Manufacturers:
1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type and materials to match those provided for supply air.

2.9 WALL SUPPLY REGISTERS/GRILLES

A. Manufacturers:
1. **Anemostat.**
2. **Price.**
3. **Titus.**

B. Type: Streamlined and individually adjustable blades, 3/4 inch minimum depth, 3/4 inch maximum spacing with spring or other device to set blades, double deflection.

C. Frame: 1 inch margin with countersunk screw mounting and gasket.

D. Fabrication: Steel with 20 gauge minimum frames and 22 gauge minimum blades, steel and aluminum with 20 gauge minimum frame, or aluminum extrusions, with factory off-white baked enamel finish.

E. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.

2.10 WALL EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:
   1. **Anemostat.**
   2. **Price.**
   3. **Titus.**

B. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, horizontal face.

C. Frame: 1 inch margin with countersunk screw mounting.

D. Fabrication: Steel or aluminum with 20 gauge minimum frames and 22 gauge minimum blades, with factory off-white baked enamel finish.

E. Damper (only if specifically called for on drawings): Integral, gang-operated, opposed-blade type with removable key operator, operable from face.

2.11 LINEAR WALL REGISTERS/GRILLES

A. Manufacturers:
   1. **Anemostat.**
   2. **Price.**
   3. **Titus.**

B. Type: Streamlined blades with 15 degree deflection, 1/8 x 3/4 inch on 1/4 inch centers.

C. Frame: 1 inch margin with countersunk screw mounting and gasket.

D. Fabrication: Steel or aluminum extrusions, with factory off-white enamel finish.

E. Damper: Integral gang-operated opposed blade hinged single blade damper with removable key operator, operable from face.

2.12 LOUVERED PENTHOUSE

A. Manufacturers:
   1. **Greenheck.**
   2. **Industrial Louvers Inc.**
   3. **Ruskin.**

B. Fabrication: Completely welded assembly. Fabricate with mitered corners. Structural supports rated for 20 psf wind and snow loading. Furnish sill water catch with 2 inch high water stop and depth to enclose structural supports.

C. Roof: Aluminum construction, standing seam type with formed water baffle plates open at corners for drainage.

D. Bird Screen: Interwoven wire mesh of aluminum, 0.063 inch diameter wire, 1/2 inch open weave.

E. Roof Curb: 12 inch inch high self-flashing galvanized steel construction with continuously welded seams 1 inch insulation and curb bottom, hinged curb adapter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify LAWA for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Carefully install all ceiling mounted air distribution devices back pan insulation and vapor barrier. Where pre-molded insulation and vapor barrier is not furnished as an accessory to the air distribution device by the manufacturer the Contractor is responsible for field installation of insulation and vapor barrier for ceiling air distribution device back pans.

E. All visible interior surfaces of all grilles and air device accessories and components visible through the face of the outlet shall be factory painted flat black.

F. Install a manual volume damper in the branch duct to the air distribution device or at the conical bell-mouth spin-in fitting for connection of round flexible duct to the rectangular duct for balancing purposes.

G. Provide all required blank off for directional pattern.

H. Diffusers Utilizing a Plenum Box: Provide plenum box fabricated of 24 USBG galvanized steel, with internal surfaces lined with minimum 1/2 inch thick duct liner.

I. Install return and exhaust registers with blades oriented to prevent sight though outlets.

J. Transfer Grilles: Provide 2 grilles, one on each side of wall with connecting sheet metal collar.

K. Transfer Ducts: Provide 2 grilles, one at each end of duct.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles before starting air balancing.

END OF SECTION 23 37 00

SECTION 23 40 00 - HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Activated carbon filters.
2. Extended surface rigid air filter with synthetic media.
3. Disposable panel filters.
4. Filter gages.
5. Bipolar Ionization.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 850 - Commercial and Industrial Air Filter Equipment.

B. American Society of Heating, Refrigerating and Air Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

C. Underwriters Laboratories Inc.:

1. UL 586 - High-Efficiency, Particulate, Air Filter Units.
2. UL 867 - Electrostatic Air Cleaners.
3. UL 900 - Air Filter Units.

1.3 SUBMITTALS

A. Shop Drawings: Indicate filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.

B. Product Data: Submit data on filter media, filter performance data, dimensions, and electrical characteristics.

C. Submit performance data for this application including initial pressure drop, recommended replacement pressure drop and maximum pressure drop.

D. Manufacturer's Installation Instructions: Submit assembly and change-out procedures.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 WARRANTY

A. Provide one-year minimum.

PART 2 - PRODUCTS

2.1 ACTIVATED CARBON FILTERS

A. Description: Efficiencies as listed by ASHRAE 52.2. : MERV 8 (25-30%)

B. Manufacturers:
   1. American Air Filter Flanders.
   2. Barnebey Sutcliffe, Division of Calgon Corporation.
   3. Or Approved Equal.

C. Assembly: Stainless steel filter racks to accommodate filter servicing trays for upstream /downstream side installation.
   1. Cassettes nominal size: 12 x 24 x 12; 20 x 20 x 12; 20 x 24 x 12 and 24 x 24 x 12 inches.

D. Media:
   1. Activated Carbon Density: 1.9 lbs/ cu ft. Non- impregnated media. Rating: Initial resistance not to exceed 0.43" w.g. at 500 fpm

2.2 EXTENDED SURFACE RIGID AIR FILTER WITH SYNTHETIC MEDIA.

A. Description: Efficiencies as listed by ASHRAE 52.2: MERV 14 (80-85%)

B. Manufacturers:
   1. American Air Filter Flanders.
   2. Camfil-Farr.
   3. Or Approved Equal.

C. Media: UL 900 Class 2, pleated, lofted, non-woven, reinforced synthetic fabric or fine, glass fiber laminated to synthetic backing.
   1. Frame: Stainless steel.
   2. Nominal size: 24 x 24 inches and 12x 24
   3. Nominal thickness: As required for scheduled efficiency rating.

D. Tested per ASHRAE 52.1:
   1. Dust spot efficiency: See schedule on drawings.
   2. Weight resistance: See schedule on drawings.
   3. Initial resistance at 500 fpm face velocity: See schedule on drawings.
   4. Recommended final resistance: See schedule on drawings.

2.3 DISPOSABLE PANEL FILTERS

A. Description: Factory-fabricated, dry, extended-surface filters with stainless steel holding frames. Efficiencies as listed by ASHRAE 52.2 MERV 8 (25-30%)

B. Manufacturers:
   1. Tridem.
   2. Camfil-Farr
   3. American Air Filter Flanders.

C. Media: Synthetic glass fibrous material and other media pleated, UL Class II, into deep-V-shaped pleats and held by self-supporting wire grid.
   1. Nominal Size: 24 x 24 inches and 12x24 inches
   2. Thickness: 1 or 2 inch.

D. Media and Media-Grid Frame: Nonflammable glass fiber, synthetics and other media to ensure adequacy for jet fuel.

E. Performance Rating:
   1. Face Velocity: 500 fpm.
   2. Initial Resistance: 0.15 inch WG.
   3. Recommended Final Resistance: 0.50 inches WG.

F. Duct-Mounting Frames: Stainless steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.
   1. Manufacturer:
      a. Pyramid Filters.
      b. Perkins Thermal Systems.
      c. Guru Filtration System.

2.4 FILTER GAGES

A. Manufacturers:
   1. Dwyer.
   2. Trerice.
   3. Weiss.

B. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case. Furnish vent valves, black figures on white background, front calibration adjustment, range 0-3.0 inch WG 2 percent of full scale accuracy.

C. Accessories: Static pressure tips with integral compression fittings, 1/4 inch plastic tubing, 2-way or 3-way vent valves.

2.5 BIPOLAR IONIZATION

A. Manufacturers
   1. Plasma Air International.
   2. Aerisa.
   3. AtmosAir.

B. Performance Criteria. The bipolar ionization system shall be capable of:
   1. Controlling gas phase contaminants generated from human occupants as well as products of combustion of jet fuel.
   2. Reducing static space charges.
   3. Reducing common VOCs encountered in airport terminals and associated buildings.
   4. Performing in non-condensing atmospheres at temperatures up to 140 degrees F.
   5. Providing between 500 and 1500 positive and negative ions per cubic centimeter or area served.

C. Equipment Requirements
   1. The bipolar ionization units shall be separately fused and an on/off service switch, indicating lamps for power available and ionization ON, a five position ion level selector switch capable of adjusting from 50% to 100% and a relay with isolated low voltage contacts to indicate unit status.
   2. All components of ionization units installed in the Air Handling Unit (AHU) shall be contained in one enclosure. Separate ionization unit and associated power generator are not acceptable. Penetrating the AHU with line voltage power conduit is not allowed.
   3. The ion generators shall be UL certified for Standard 867. The ion generators certified for residential application only shall not be accepted. Product's nameplate must match the UL certified manufacturer's name. Ionization Tubes shall be UL listed and bear the UL mark and have minimum useful life of 8,800 hours before replacement is required.
   4. The electric power wiring to the ionization unit shall be detachable without the use of tools to facilitate servicing of the equipment. Quick release system shall utilize a screw down coupler. System utilizing metallic latches shall not be accepted due to corrosion and inoperability over time.
   5. All exposed metallic parts of ionization tubes shall be stainless steel.
   6. Ionization units shall be suitable for duct mounting or air handling unit plenum mounting.
   7. The bipolar ionization unit shall carry a five (5) year warranty. Warranty shall remain in force as long as the OEM tubes are replaced on an annual basis.

D. Equipment Application.
   1. Ionization units shall be installed per manufacturer's installation instructions.
   2. Each AHU shall include the required number of ion generators sized to that AHU airflow capacity. Each ion generator shall have minimum five (5) glass ionization tubes with nominal ionization capacity to treat 10,000 CFM. Quantities shall be rounded up.
   3. The bi-polar ionization system shall be installed downstream of all filters.

4. Electrical power to the ion generator shall be interrupted when the airflow in less than 100 fpm or when access doors to the ionization plenum are opened.
5. For AHUs that contain two (2) ion generators or more, a remote monitoring panel shall be provided at each AHU and shall include: 16 gauge galvanized steel NEMA 3R enclosure, and permanently attached engraved name plates. All internal components shall be UL recognized. For each ion generator within the AHU provide on/off switch, "alarm " and "status" indicating lamp and form C contacts to interface with BMS to alert service required.
6. Ion generators shall be installed on stationary front service rack. The rack assembly shall be factory fabricated. Interconnecting wiring shall carry voltage no higher than the primary source to the remote panel.
7. Each vendor shall provide to LAWA a portable hand- held ion counter with a calibrated range of 0 to 20,000 ions/cm^3 and an accuracy +/- 25% within the specified range. Ion counter shall have automatic zeroing capability on 10 minute intervals.
8. For each AHU fitted with ion generator provide a duct mounted ion sensor powered from 12V DC or 24V AC. Ion sensor to be user adjustable from 500 to 20,000 ions per cm^3 and contain a dry contact for integration with the Building Automation System (BAS). Contacts shall be closed when the minimum ion density settings are achieved. Sensor housing shall be ABS or aluminum.

E. Electrical Requirements

1. The electrical power wiring to the ionization units shall be detached without the use of tools to facilitate servicing of the equipment.
2. Ionization units shall be available for 120 volt applications.
3. The maximum power required for multi tube ionization units shall be 50 watts.
4. The electrical contractor shall provide a junction box with single outlet within 4 feet of the ionization equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filters with felt, rubber, or neoprene gaskets to prevent passage of unfiltered air around filters.

B. Install filter gage static pressure tips upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum, in accessible position. Adjust and level.

C. Do not operate fan system until temporary filters are in place. Replace temporary filters used during construction and testing, with clean set.

D. Install filter gages on filter banks with separate static pressure tips upstream and downstream of filters.

E. Install filters in accordance with manufacturer's recommendations.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Provide minimum of 12 hours each (3 shifts) of classroom and hands on training to LAWA Facilities and Maintenance Division personnel.

END OF SECTION 23 40 00

SECTION 23 41 00 – PHOTOCATALYTIC OXIDATION (PCO) SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following: UL listed Photocatalytic Oxidation using TiO_2 media.

1.2 REFERENCES

A. Air Movement and Control Association International, Inc.:

AMCA 99 - Standards Handbook.
AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

B. Air-Conditioning and Refrigeration Institute:

ARI 430 - Central-Station Air Handling Units (AHU)
ARI Guideline D - Application and Installation of Central Station Air Handling Units.

C. Underwriters Laboratories Inc Standards.:

UL 900 - Air Filter Units.
ULC-S111 - Standard Method of Fire Tests for Air Filter Units.
UL 1598 – Luminaires.
UL Category Code ABQK (accessories, Air Duct mounted).

1.3 SUBMITTALS

A. Product Data: Manufacturer's literature for Photocatalytic Oxidation System should indicate:

1. Dimensions, weights, capacities and ratings.
2. Catalog cuts, engineering data sheets, list of unit numbers, UVC lamps output and power consumption
3. Wiring diagrams, fixtures and control panel.
4. Provide installation, operation and maintenance manuals
5. Photocatalytic Oxidation Unit components and accessories, including number and length of UVC lamps required to activate the TiO_2 media.
6. Heat output of lamps into AHU or air stream for each size of air handling unit scheduled.

Calculated intensity profile of entire irradiated surface demonstrating minimum intensity (mW/cm^2). System manufacture shall be able to provide printed graphical representation of UV surface intensity on the PCO panel(s) as required.

1.4 QUALITY ASSURANCE

A. System to be factory tested and the design, construction and installation to be in accordance with all state, local, federal or other regulations having jurisdiction.

B. Competency of Supplier/Manufacturer/Installer

1. The supplier/manufacturer/installer of the Photocatalytic Oxidation system to have a qualified service organization in active operation for a minimum of five (5) years. The organization to have had a history of competent service experience in designing, installing and maintaining the specific types of systems described in the specifications, and has on its payroll sufficient qualified experienced personnel to guarantee satisfactory performance of the installation. All maintenance personnel used in fulfilling the requirements of the installation shall be qualified to maintain this type of equipment.

1.5 WARRANTY

A. The Photocatalytic Oxidation system, less lamps, shall be warranted free from defects in material and workmanship for a period of five (5) years.

PART 2 - PRODUCTS

2.1 PHOTOCATALYTIC OXIDATION

A. MANUFACTURERS

1. **Genesis Air/IAQ Solutions, Inc**
2. **UVDI**
3. **Trane Photocatalytic Air Cleaner**

B. DESCRIPTION

1. Provide photocatalytic oxidation for bacteria, mold, and odor control (including organic fuel exhaust fumes) inside each equipment it is installed. The UV dosage shall be calculated for theoretical 99% air disinfection at air velocity and temperature and shall be adequate to deactivate microbial growth on all exposed surfaces within the irradiated profile. Unit shall be rated for a maximum air velocity across the unit face of 500 feet per minute.
2. Casing shall be of single wall construction, fabricated of 24 gauge 304 Stainless Steel, or 22 gauge Galvanized Steel. All elements of casing shall be free from sharp edges and burrs. Casing shall be between 5 ½" and 6" deep.
3. The multi-component system to allow for optimum performance: UVC lamps, their supporting structure, one or two stage of the PCO molecular filtration elements, consisting of the PCO catalyst panels, their modular support frames, high VOC adsorbent panels and modular support frames. The UVC support structure shall have option of inside or outside servicing.
4. The lamp support structure shall also allow for the inside and the outside servicing and shall be engineered and designed to be installed in the AHU. The lamp support structure shall consist of one or more vertical struts, custom fabricated from Stainless Steel or Galvanized Steel, to properly locate the UVC lamps, both vertically and horizontally. In the outside servicing configuration, lamps shall be accessible from the exterior service door. The lamps shall slide out on the rails or slides. Lamps for both

configurations shall have easy and quick connectors for ease of lamps access and replacement. Lamps shall be spaced vertically at between 9" and 14" (12" nominal) on center . Lamp support structure shall be completely independent of the PCO catalytic panels and their supports.

5. Ballast hall be enclosed in metal enclosure with attached wiring to connect the ballast to the lamp

6. Safety limit switches and exterior SPST On/Off switches shall be pre-wired and factory installed in a weatherproof junction box. All exterior safety signage shall be permanently affixed to each access door having direct line of sight to the lamps with UL warning requirements. The photocatalyst unit shall be complete with all miscellaneous accessories required to form a complete unit.

7. Photocatalytic Oxidation (PCO) shall be one of the two types below:

   a. Photocatalytic Oxidation (PCO) media shall consist of 6 six-inch (nominal) non-metallic media with face area to match casing opening, pleated at one pleat per inch (nominal), with a minimum of 40 and maximum 200 nanometer TiO_2 coating. PCO media shall be placed perpendicular to the air stream in the unit casing. Media shall have an internal mechanism to eliminate the silica produced by the oxidation of ethanol. Unit shall be configured to operate with 120V/1ph/60Hz. electrical power. Unit shall be provided with junction box. Racking System shall be constructed of Galvanized Steel as either a face loading or a side-loading design. Either system must show proof of conformance with ICC AC -156. The catalyst, accessory panel, and the racking system shall bear an OSP certification number. Lamps and ballasts shall be designed specifically to provide type-C ultraviolet light with a wavelength at or near 2537 Angstroms. Lamps shall be non-ozone-producing. Lamps shall be Teflon-coated to reduce breakage. Sufficient lamps shall be provided and positioned through the pleats of the catalyst media equidistant from edges to achieve a minimum coverage of 9.5 milliwatts per square inch of UVC light, upstream and downstream, across all exposed surfaces of the PCO media. Lamp UVC output shall not drop below 9.5 milliwatts per square inch over their usable 12,000 hr. life.

   b. Photocatalytic Oxidation (PCO) photocatalyst media shall be irradiated with a minimum, average irradiance of 3,000 microwatts per square centimeter (19.35 milliwatts per square inch) across the entire plane/bank of the catalyst. The substrate shall be coated with Titanium Dioxide (TiO2) at minimum of 5 micrometers in thickness. The TiO2 shall consist of a mixture of nanophase and microphase particles in anastase crystalline form, ranging from 60 nanometers to 200 nanometers. The catalyst media shall consist of self-supporting aluminum honeycomb substrate 3/4" inch thick in direction of air flow, with 1/8" inch nominal cell size, at 70 cell per square inch of panel face, resulting in minimum substrate surface area of 2,000 square inches per square foot of catalyst face surface area. Lamps and ballasts shall be designed specifically to provide type-C ultraviolet light with a wavelength at or near 2537 Angstroms. Lamps shall be non-ozone-producing. Lamps shall be Teflon-coated to reduce breakage. Sufficient lamps shall be provided to achieve a minimum coverage of 9.5 milliwatts per square inch of UVC light, upstream and downstream, across all exposed surfaces of the PCO media. Lamp UVC output shall not drop below 9.5 milliwatts per square inch over their usable 12000 hr. life.

8. Independent Testing. The device submitted shall be classified by UL (Underwriters Laboratories) as an Air Duct Mounted Accessory (ABQK) and also meet the UL Standards 1598, UL 153, UL 1995. Manufacturers UL file number shall be permanently marked on the exterior of the product. UL compliance is to be verified by the UL Online Certifications Directory.
9. The assembly shall employ a safety interlock switches, which interrupts power when the Air Handler is opened for servicing. The product employs germicidal lamps, which emit UV-C radiation, thereby posing a potential risk of exposure to eyes and bare skin during maintenance. Access doors shall have a glass visual examination port as provided by air handling equipment manufacturer. Warning signage with UL Safety Requirements , provided by PCO equipment manufacturer, shall be permanently mounted on each access door with direct line of sight to the lamps.. No PCO system shall be operational without active UV lights. The AHU manufacturer shall provide safety interlock, disallowing operation of the supply fan when the UV lights are inactive.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install PCO system as indicated in the contract documents, in accordance with the industry standards and per manufacturer's recommendation.

3.2 DEMONSTRATION AND TRAINING

A. See LAWA Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Train LAWA Maintenance personnel to adjust, operate and maintain the system.

C. Provide minimum of 12 hours each (3 shifts) of classroom and hands on training to LAWA Maintenance personnel.

END OF SECTION 23 41 00

SECTION 23 42 00 - ULTRA VIOLET GERMICIDAL IRRADIATION (UVGI) SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. UL listed indoor air quality system (UVGI) mounted inside air handling units and packaged units.

1.2 SUBMITTALS

A. Product Data: Manufacturer's literature for UVGI Systems indicated.

1. Dimensions, weights, capacities and ratings.
2. Wiring diagrams, fixtures and control panel.
3. UVGI system components and accessories.
4. Heat output of UVGI system into air handling unit or air stream for each size of air handling unit scheduled.

B. Catalog cuts, engineering data sheets, list of unit numbers, UVGI output and power consumption. The following shall also be included with submittals:

1. Indoor air quality systems: Calculated lamp watts per square foot of coil shall demonstrate greater than 6 lamp watts per square foot of coil, consistent with ASHRAE 2011 Handbook, Chapter 60.8.

C. Operation and Maintenance Data: For UVGI systems to include in emergency operation and maintenance manuals:

1. Provide catalog cuts of equipment and components.
2. Include instructions for lamp replacement and component replacement.
3. Provide spare parts list.
4. Provide wiring diagram.
5. Provide installation, operation and maintenance manuals.

1.3 QUALITY ASSURANCE

A. System to be factory tested and the design, construction and installation to be in accordance with all state, local, federal or other regulations having jurisdiction.

B. Competency of Supplier/Manufacturer/Installer

1. The supplier/manufacturer/installer of the UVGI system to have a qualified service organization in active operation for a minimum of five (5) years. The organization to have had a history of competent service experience in designing, installing and maintaining the specific types of systems described in the specifications, and has on its payroll sufficient qualified experienced personnel to guarantee satisfactory

performance of the installation. All maintenance personnel used in fulfilling the requirements of the installation shall be qualified to maintain this type of equipment.

1.4 WARRANTY

A. The UVGI system, less lamps and ballasts, shall be warranted to be free from defects in material and workmanship for a period of five (5) years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, acceptable manufacturers are:

1. **Steril-Aire**
2. **UV Resources**
3. **UVDI**

2.2 UVGI ULTRAVIOLET DISINFECTION

A. Provide ultraviolet disinfection for bacteria and mold control inside each equipment it is installed in. The UV dosage shall be adequate to deactivate microbial growth on all exposed surfaces. Fixtures shall be installed in sufficient quantity to provide a minimum of 6 UV-C lamp Watts per square foot of coil surface area, consistent with ASHRAE 2011 Handbook, Chapter 60.8.

B. Construction. The UV System shall be designed and constructed of 304 stainless steel for mounting anywhere in the system, or as shown in the plans. Any exposed screws or fasteners shall be Stainless Steel. Safety limit switches and Exterior SPST On/Off switches shall be pre-wired and factory installed in a weatherproof junction box. All exterior safety signage shall be permanently silk-screened with UL warning requirements. Lamp supports shall be Stainless Steel. The lamps shall easily be removed for service without the use of tools or the disconnection of any wiring connections. UV System shall be complete with all miscellaneous accessories required to form a complete unit.

C. Independent Testing. The device submitted shall be classified by UL (Underwriters Laboratories) as an Air Duct Mounted Accessory (ABQK). Also meets the UL Standards 1598, UL 153, UL 1995. Manufacturers UL/ETL file number shall be permanently marked on the exterior of the product.

D. Ultra Violet Lamps. The lamp shall be available on the open market and not be prioritized in relationship to the UV equipment. Lamp Watts shall be printed on all lamps, no exceptions. They shall be high output (HO), T5 diameter, hot cathode, mini/medium bi-pin types that produce UV-C energy primarily at the 254nm wavelength. Lamp shall be coated with FEP (Teflon™) to encapsulate glass and mercury in case of lamp breakage. Each lamp shall contain no more than 8 mg of mercury and be capable of operating in air temperatures of 1-70° C, and any velocity. Useful lamp life shall be 9000 hours (minimum) with no more than a 15% output loss at the end of the lamps life. They shall not produce measurable ozone.

Current replacement lamp costs shall be an integral part of submittal data. The Lamp Change shall be performed without UV fixture disassembly and without the use of tools. The product shall not require maintenance personal to enter the wiring compartment of in order to facilitate lamp change.

1. Manufacturer.

    a. **Philips**
    b. **LSI**
    c. **Sylvania**

E. Ballasts. The ballast shall be available on the open market and not be prioritized in relationship to the UV equipment. Ballasts shall be and UL Listed for the lamp provided. Ballasts shall be high power factor, class P, Sound Rating A, Type 1 Outdoor, Electronic. Ballasts shall be suitable for air handling spaces and shall have harmonic distortion in accordance with ANSI standards and a minimum operating temperature of 20 degrees F. Ballasts shall be warranted for a period of 5 years.

1. Manufacturer.

    a. **Advance**
    b. **Visualite**
    c. **Fulham**

F. Safety. The assembly shall employ a safety interlock switches, which interrupts power when the Air Handler is opened for servicing. The product employs germicidal lamps, which emit UV-C radiation, thereby posing a potential risk of exposure to eyes and bare skin during maintenance. Access doors shall have a glass visual examination port as provided by equipment manufacturer. Warning signage provided by UV equipment manufacturer shall be silk-screened with UL requirements as to safety aspects.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's recommendation.

3.2 TRAINING

A. See LAWA Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Train LAWA Maintenance personnel to adjust, operate and maintain the system.

C. Provide minimum of 12 hours each (3 shifts) of classroom and hands on training to LAWA Maintenance personnel.

END OF SECTION 23 42 00

SECTION 23 57 00 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes shell and coil, shell and tube, and plate heat exchangers.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, dimensions, furnished specialties, and accessories. Provide Los Angeles City Research Report Approval Letter or Los Angeles City One-Time Approval.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Detailed drawings.
4. Strength of material calculations.

C. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other:

1. Heat Exchanger shown to scale with maintenance access space.
2. Structural members to which heat exchangers will be attached.

1.3 QUALITY ASSURANCE

A. ASME Compliance:

1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
2. Provide all documentation that vessels have passed ASME testing including ASME A-1 form.
3. Provide ASME manufacturer’s data report NO. U-1 for shell and coil units.

B. Factory hydraulically tested to at least 1.5 times specified working pressure for the shell and tube, and shell and coil heat exchanges, and 1.3 times specified working pressure for the plate heat exchanger.

1.4 EXTRA MATERIALS

A. Provide two sets of replacement gaskets for the shell and tube as well as plate heat exchangers.

B. Provide two sets of wrenches for disassembly of plate heat exchangers.

C. Provide stainless steel nameplates with identical tag indicating design drawings data, sizes and capacity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2. Energy Transfer Stations: Several options are enclosed for Energy Transfer Station designs.
   a. The preferred method is to have a pre-packaged skid utilizing shell and coil or shell and tube heat exchangers, that can be interconnected to the existing heating and domestic hot water systems with minimal down time. They are self-contained and compact in design.

2.2 SHELL AND COIL HEAT EXCHANGERS FOR HEATING ENERGY TRANSFER STATIONS (PACKAGED OPTION)

A. Manufacturers:

1. Elge (as manufactured by Alstrom Heat Transfer LLC).

2. Alfa Laval.

3. Taco.

B. Configuration:

1. Equipment to be skid mounted and ready to install consisting of vertical shell and coils for space heating, domestic water heating, piping, isolation valves, control valves and controls.
2. Heat exchangers to be counter cross-flow heat exchangers,
3. Pressure drop on domestic water side at no more than 3psig.
4. Heat exchangers to conform to the latest ASME Code for pressure vessels for maximum operating pressure 250 psig at 600 deg F maximum operating temperature.

C. Single wall units (heating HX): Consists of a copper coil within a pressure vessel. Coil is manufactured from drawn, smooth, spiral wound copper tubes with an oval cross section. The tubes are separated by spacers forming channels with uniform counter cross-flow areas.

D. Double wall units (domestic water HX): Consists of copper coil within a pressure vessel. This coil is manufactured from drawn, smooth, spiral wound copper tubes. The copper tubes are joined to a tube sheet and chamber with low flow resistance.

E. Materials:

1. Pressure head: carbon steel hemispherical heads.
2. Copper tube: 3/8” copper tubing with 22 gauge wall.
3. Shell: Steel

4. Coil Connections: copper type L.
5. Heat exchangers to be insulated with 2" fiberglass and jacketed with aluminum jacketing for protection.

F. Accessories

1. Isolation valves so each HX may be removable without interruption of service.
2. Isolation valves at skid connections for attaching to existing heating water system.
3. Hose connections for chemical cleaning and flushing of shell and coils.
4. Temperature control valve
   a. Actuator – 24 VAC
   b. Valve body – two way cylinder balanced valve for higher pressures
   c. Valve internals to be stainless steel
   d. Shut-off: ANSI Class IV.
5. Flow and pressure controller.
   a. Valve body – cast steel rated for 560 PSI
   b. Valve internals to be stainless steel
   c. Two actuators - One for pressure control and one for flow control
      (1) Actuators shall be removable without shutting down water flow
      (2) Thermostatic non-electric operating according to the liquid expansion principle
   d. Controller will be self-acting proportional for pressure and flow control and monitoring
6. Over heat protection and alarm with ½" blowdown with solenoid valve
7. Thermometer in water inlets and outlets.
8. ASME rated temperature and pressure relief valve in water outlet.
9. ASME rated pressure relief valve on each shell and coil heat exchanger in water outlet.
10. Pressure gage with pet cock.
11. Skid mounted on a steel skid primed and painted.
12. Package factory pressure tested.

2.3 SHELL AND TUBE HEAT EXCHANGERS FOR HEATING ENERGY TRANSFER STATIONS (PACKAGED OPTION)

A. Manufacturers:

1. Alfa Laval Thermal, Inc.
2. Taco.
3. Standard Xchange.

B. Configuration:

1. Equipment to be skid mounted and ready to install consisting of shell and tube for space heating, domestic water heating, piping, isolation valves, control valves and controls.
2. Heat exchangers to be counter cross-flow heat exchangers,
3. Pressure drop on domestic water side at no more than 3 psig.

4. Heat exchangers to conform to the latest ASME Code for pressure vessels for maximum operating pressure 250 psig at 600 deg F maximum operating temperature.

C. Single wall units (heating HX): Consists of a copper coil within a pressure vessel. Coil is manufactured from drawn, smooth, spiral wound copper tubes with an oval cross section. The tubes are separated by spacers forming channels with uniform counter cross-flow areas.

D. Double wall units (domestic water HX): Consists of copper coil within a pressure vessel. This coil is manufactured from drawn, smooth, spiral wound copper tubes. The copper tubes are joined to a tube sheet and chamber with low flow resistance

E. Materials:

1. Pressure head: carbon steel hemispherical heads.
2. Copper tube: 3/8" copper tubing with 22 gauge wall.
3. Shell: Steel
4. Piping Connections: shell and head flanged inlet and outlet connections.
5. Heat exchangers to be insulated with 2" fiberglass and jacketed with aluminum jacketing for protection.

F. Accessories

1. Isolation valves so each HX may be removable without interruption of service.
2. Isolation valves at skid connections for attaching to existing heating water system.
3. Hose connections for chemical cleaning and flushing of shell and coils.
4. Temperature control valve
   a. Actuator – 24 VAC
   b. Valve body – two way cylinder balanced valve for higher pressures
   c. Valve internals to be stainless steel
   d. Shut-off: ANSI Class IV.
5. Flow and pressure controller.
   a. Valve body – cast steel rated for 560 PSI
   b. Valve internals to be stainless steel
   c. Two actuators - One for pressure control and one for flow control
      (1) Actuators shall be removable without shutting down water flow
      (2) Thermostatic non-electric operating according to the liquid expansion principle
   d. Controller will be self-acting proportional for pressure and flow control and monitoring
6. Over heat protection and alarm with ½" blowdown with solenoid valve
7. Thermometer in water inlets and outlets.
8. ASME rated temperature and pressure relief valve in water outlet.
9. ASME rated pressure relief valve on each shell and coil heat exchanger in water outlet.
10. Pressure gage with pet cock.
11. Skid mounted on a steel skid primed and painted.
12. Package factory pressure tested.

2.4 BRAZED PLATE HEAT EXCHANGERS FOR HEATING ENERGY TRANSFER STATION (FIELD ASSEMBLED)

A. Manufacturers:

1. Alfa Laval Thermal, Inc.

2. Invensys APV, Inc.

3. Xylem; Bell & Gossett.

B. Configuration:

1. Brazed factory fabricated assembly consisting of two end plates, one with threaded nozzles and pattern-embossed plates.
2. Units for domestic hot water shall be suitable construction conforming to local codes. Units shall be of double wall construction with air vent leak path. This option would be a field assembled (or prepackaged) alternate to the shell and coil unit specified in paragraph 2.2.
3. End-Plate Material: Type 316 stainless steel.
4. Threaded Nozzles: Type 316 stainless steel.
5. Plate Material: Type 316 stainless steel.
6. Brazing Material: Copper or nickel.
7. Capacity and Characteristics: See equipment schedule on drawings

2.5 PLATE HEAT EXCHANGERS

A. Manufacturers:

1. Alfa Laval Thermal Inc.

2. Invensys.

3. Bell & Gossett.

B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

1. Frame: Capacity to accommodate 20 percent additional plates. Painted carbon steel with provisions for anchoring to support.
2. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
3. End-Plate Material: Painted carbon steel.
4. Plate Material: 0.031 inch thick before stamping; Type 316 stainless steel.
5. Gasket Material: EPDM.
6. Piping Connections: Threaded port for NPS 2 and smaller. For larger sizes, furnish nozzle with flanged connection.
7. Enclose plates in a solid stainless-steel removable shroud.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT-EXCHANGER INSTALLATION

A. Install heat exchangers and accessories in accordance with manufacturer's instructions. Install so that heat exchangers can be removed without disturbing other equipment or piping. Insulate heat exchanger for personnel protection and heat retention.

B. Install heat exchangers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

C. Concrete Bases: Anchor heat exchanger to concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Maintain manufacturer's recommended clearances for service, maintenance and repair / replacement. Install piping connections to allow service, maintenance and repair/replacement of heat exchangers.

C. Install shutoff valves at heat-exchanger inlet and outlet connections.

D. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

E. Install hose end valve to drain heat exchangers.

3.4 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

C. Provide minimum of 8 hours each (3 shifts) of classroom and hands on training to LAWA Facilities and Maintenance personnel.

END OF SECTION 23 57 00

SECTION 23 64 11 - PACKAGED WATER CHILLERS - RECIPROCATING, SCROLL, AND SCREW

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes chiller package, charge of refrigerant and oil, controls and control connections, chilled water connections, condenser water connections, refrigerant connections, auxiliary water connections, starters.

B. This applies to chillers smaller than 100 tons.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 550/590 - Water Chilling Packages Using the Vapor Compression Cycle.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. American Society of Mechanical Engineers:

1. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.

D. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings: Indicate components, assembly, dimensions, weights and loads, required clearances, and location and size of field connections. Indicate valves, strainers, and thermostatic valves required for complete system.

B. Product Data: Submit rated capacities, weights, specialties and accessories, electrical requirements, wiring diagrams, and control diagrams.

C. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include startup instructions.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements including those furnished but not produced by manufacturer.

E. Manufacturer’s Field Reports: Submit start-up report. Indicate results of leak test and refrigerant pressure test.

1.4 CLOSEOUT SUBMITTALS

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

1.5 WARRANTY

A. Furnish five-year manufacturer warranty to include coverage for complete assembly including materials and labor.

1.6 MAINTENANCE SERVICE

A. Furnish service and maintenance of chiller for five years from Date of Substantial Completion.

B. Examine unit components monthly. Clean, adjust, and lubricate equipment.

C. Include systematic examination, adjustment, and lubrication of unit, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

D. Perform work without removing units from service during building normal occupied hours.

E. Provide emergency call back service at all hours for this maintenance period.

F. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.

G. Perform maintenance work using competent and qualified personnel under supervision and in direct employ of manufacturer or original installer.

1.7 MAINTENANCE MATERIALS

A. Furnish two containers of lubricating oil.

PART 2 - PRODUCTS

2.1 PACKAGED WATER CHILLERS

A. Manufacturers:
   1. **York.**
   2. **Carrier.**
   3. **Trane.**

B. Product Description: Factory assembled and tested, packaged, water cooled, liquid chillers consisting of compressors, compressor motor, condenser, evaporator, refrigeration

accessories, instrument and control panel including gauges and indicating lights, auxiliary components and accessories, and motor starters.

C. Refrigerant shall be R-410A or R-407C.

2.2 HERMETIC COMPRESSORS

A. Reciprocating Compressors:

1. Unit: Hermetically sealed motor-compressor with crankcase heater, suction and discharge service valves, rubber-in-shear isolators, and control panel.
2. Motor: Constant speed 3600 rpm, suction gas cooled with overheating protection.
3. Crankcase Heater: Energize continuously.

B. Scroll Compressors:

1. Unit: Direct drive, hermetic, 3600 RPM, fixed compression, scroll motor-compressor with control panel.
2. Features: Centrifugal oil pump, sump oil heater, oil level sight glass, oil charging valve, two point lubrication for each motor bearing, flooded lubrication for journal and thrust bearings, check valve on scroll discharge port.
3. Motor: Suction gas-cooled, hermetically sealed, squirrel cage induction.
4. Automatic Capacity Reduction: Electronic logic controller and air temperature sensor controls unit and hot gas bypass regulator valve.

2.3 SEMI-HERMETIC COMPRESSORS

A. Reciprocating Compressors:

1. Unit: Serviceable hermetic reciprocating motor-compressor with positive displacement oil pump lubrication system, spring loaded heads and replaceable cylinder liners, crankcase heater, suction inlet screen, discharge service valves, and control panel.
2. Automatic Capacity Reduction Equipment solenoid gas pressure operated. Furnish capability for unloaded compressor start.
3. Motor: Constant speed 1800 rpm, suction gas cooled with electronic overheating protection in each phase, reduced voltage starting.
4. Crankcase Heater: Energize continuously.

B. Screw Compressors:

1. Unit: Direct drive, semi-hermetic 3600 RPM, fixed compression, rotary screw compressor with control panel.
2. Features: Differential refrigerant pressure oil pump, oil heater, oil separator and filter and oil charging valve.
3. Motor: Suction gas-cooled, hermetically sealed, squirrel cage induction.
4. Automatic Capacity Reduction: Continuously variable slide valve with infinitely variable control to 25 percent of full load.

2.4 EVAPORATOR

A. Shell and tube type, seamless steel construction with fabricated steel, heads, seamless copper tubes with integral fins, rolled into tube sheets. Furnish multiple refrigerant circuits on multiple compressor units.

B. Design, test, and stamp refrigerant side for 225 psig working pressure and water side for 150 psig working pressure, in accordance with ASME Section VIII.

C. Insulate with 0.75 inch minimum thick flexible expanded polyvinyl chloride insulation with maximum K factor of 0.26.

D. Furnish water drain connection and thermometer wells for temperature controller and low temperature cutout.

2.5 CONDENSERS

A. Shell and tube type, seamless steel construction with fabricated steel heads, seamless copper tubes with integral fins, rolled into tube sheets.

B. Design, test, and stamp refrigerant side for 450 psig working pressure in accordance with ASME Section VIII.

C. Furnish integral sub-cooling circuit.

D. Furnish 450 psig safety relief valve on condenser shell.

E. Design, test, and stamp water side for 150 psig working pressure in accordance with ASME Section VIII.

2.6 CONDENSER COILS, FANS AND MOTORS

A. Coils: Copper fins mechanically bonded to seamless copper tubing. Furnish sub-cooling circuits as applicable. Air test under water to 425 psig, and vacuum dehydrate. Seal with holding charge of nitrogen.

B. Coil Guard: Louvered with lint screens.

C. Vertical propeller type condenser fans with fan guard on discharge.

D. Weatherproof motors suitable for outdoor use, with permanent lubricated ball bearings and built-in current and thermal overload protection.

2.7 REFRIGERANT CIRCUIT

A. Factory furnished and piped.

B. Furnish for each refrigerant circuit:

1. Liquid line solenoid valve.

2. Filter dryer (replaceable core type).
3. Liquid line sight glass and moisture indicator.
4. Thermal expansion for maximum operating pressure.
5. Charging valve.
6. Insulated suction line.
7. Discharge line check valve.
8. Compressor discharge service valve.
9. Pressure relief device.

2.8 CONTROLS

A. On or near chiller, mount steel control panel with NEMA 3R (NEMA 4X for outdoors location) enclosure, containing starters, power and control wiring, molded case disconnect switch, factory wired with single point power connection.

B. For each compressor, furnish part winding starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for control power. Furnish manual reset, current overload protection.

C. Furnish devices on control panel face:

1. Compressor, run lights.
2. System start-stop switch.
3. Control power fuse of circuit breaker.
4. Compressor lead-lag switch.
5. Demand limit switch.

D. Furnish safety controls with indicating lights arranged so machine is shut down and requires manual reset:

1. Low chilled water temperature switch.
2. High discharge pressure switch for each compressor.
3. Low suction pressure switch for each compressor.
4. Oil pressure switch.
5. Flow switch in chilled water line.
6. Flow switch in condenser water line.
7. Relay for remote mounted emergency shutdown.

E. Furnish the following operating controls:

1. Multi-step chilled water temperature controller to cycle compressor and activate capacity controls, with remote thermostat.
2. Five minute off timer prevents compressor from short cycling.

3. Part winding start timer.
4. Periodic pump-out-timer to pump down on chilled water flow and high evaporator refrigerant pressure.
5. Load limit thermostat to limit compressor loading on high return water temperature.
6. Three phase monitor to protect unit by stopping compressor on phase loss, phase reversal, phase unbalance, or under voltage.
7. Hot gas bypass sized for minimum compressor loading, bypasses hot refrigerant gas to evaporator.
8. Cycle counter and operating hour meter.

F. Furnish pre-piped gauge board with pressure gauges for suction and discharge refrigerant pressures, and oil pressures.

G. Furnish alarm package with test button and lights indicating control circuit is energized, compressor is running, and sounds audible alarm and activates indicating light upon detection of compressor malfunction, low chilled water temperature, or evaporator water flow failure.

2.9 SOURCE QUALITY CONTROL (AND TESTS)

A. Furnish testing of package chillers.

B. Furnish shop inspection and testing for package chillers.

C. Make completed chillers available for inspection at manufacturer's factory prior to packaging for shipment. Furnish at least seven days notice before packaging is scheduled.

D. Allow witnessing of factory inspections and tests at manufacturers test facility by LAWA personnel. Furnish at least seven days notice before inspections and tests are scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install indoor chiller on concrete housekeeping pad minimum 3-1/2 inches high and 6 inches wider than equipment base on each side. Install packaged outdoor chiller on concrete foundation minimum 6 inches thick and 6 inches wider than equipment base on each side.

B. Provide seismic restraints as required.

C. Install the following piping accessories on evaporator chilled water piping connections.

1. On inlet:
    a. Thermometer well for temperature controller.
    b. Thermometer.
    c. Strainer.

d. Flow switch.
e. Flexible pipe connection.
f. Pressure gauge.
g. Shut-off valve.

2. On outlet:
a. Thermometer.
b. Flexible pipe connection.
c. Pressure gauge.
d. Balancing valve.

D. Install auxiliary water piping for oil cooling units and purge condensers.

E. Install the following piping accessories on condenser water piping connections.

1. On inlet:
a. Thermometer well for temperature limit controller.
b. Thermometer well and thermometer.
c. Strainer.
d. Flow switch.
e. Flexible pipe connection.
f. Pressure gauge.
g. Shut-off valve.

2. On outlet:
a. Thermometer well and thermometer.
b. Flexible pipe connection.
c. Pressure gauge.
d. Balancing valve.

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

G. Install refrigerant piping connections to air-cooled condensing units.

H. Install piping from chiller safety relief valve to outdoors. Size as recommended by manufacturer.

I. Install chiller accessories furnished loose for field mounting.

J. Install electrical devices furnished loose for field mounting.

K. Install control wiring between chiller control panel and field mounted control devices.

L. Provide connection to electrical service.

3.2 FIELD QUALITY CONTROL

A. Furnish cooling season start-up, winter season shutdown service, for first year of operation. When initial start-up and testing takes place in winter and machines are to remain inoperative, repeat start-up and testing operation at beginning of first cooling season.

3.3 MANUFACTURER'S FIELD SERVICES

A. Furnish services of factory trained representative for minimum of one day to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, calibrate controls, and instruct Owner on operation and maintenance.

B. Furnish initial charge of refrigerant and oil.

C. Train LAWA Maintenance personnel on the system operations and performance to adjust, operate and maintain the system.

3.4 DEMONSTRATION AND TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Demonstrate system operations and verify specified performance. Demonstrate low ambient operation during winter testing for air-cooled condensers.

C. Train LAWA Maintenance personnel on the system operations and performance to adjust, operate and maintain the system.

D. Training to include minimum of 15 personnel for 40 hours training, 16 hours shall be classroom training and 24 hours shall be hands-on training.

E. Training shall occur after the system is fully operational.

3.5 FACTORY PERFORMANCE TESTS

A. Manufacturer shall conduct factory performance test for each chiller in accordance with ARI 550/590, to verify design capacity and part load capacity points indicated on Bid form. LAWA and/or LAWA’s representative (2 persons) may elect to witness tests. Notify LAWA and/or LAWAs representative of test date at least 2 weeks in advanced. There will be zero tolerance on capacity and NPLV, other parameters are per ARI 550/590 tolerance.

B. Before shipment of chillers, all records and certifications approving testing requirements shall be submitted to and approved by LAWA.

C. Defective work or material shall be replaced or repaired, as necessary, and inspection and test repeated. Repairs shall be made with new materials. Run new performance test in accordance with ARI standard.

D. If chiller assembly fails to meet design capacity and a minimum of 15% more capacity at lower condenser water temperature, LAWA may elect not to accept delivery until chiller is modified at manufacturer's expense to meet design capacity.

E. If chiller assembly fails to meet any of part load performance data supplied by manufacturer with his bid, LAWA may elect not to accept delivery until chiller is modified at manufacturer's expense to meet all of design and part load performance data or to assess penalty charge equal to 10 years operating cost differential. This differential is to be determined by using part load data included in bid form and data obtained from performance test, subtracting bid data annual operating cost from test data annual operating cost, and multiplying difference by ten. Penalty charge shall apply to all chillers.

F. All design conditions and part load performance data shall be evaluated with 480 volt, 3 phase, 60 hertz power supplied to chiller.

G. Conduct test at approved ARI certified test facility of the manufacturer.

H. Instrumentation used for testing must be calibrated within 6 months of test date and traceable to National Bureau of Standards. Documentation verifying NBS traceability shall be submitted to LAWA.

1. Performance test shall be two point test for one chiller. Points will be selected at time of test. Points will be selected from submitted performance from 25 to 100% of capacity.

3.6 COMMISSIONING

A. The manufacturer shall be present during all commissioning events. The anticipated schedule is for commissioning to occur during the least six to eight weeks of construction just prior to the anticipated end of construction date of. Include 40 hours of field time to perform the commissioning requirements.

B. A factory authorized representative shall perform the startup service.

1. Fill out startup checklists and attach copy with Contractor Startup Report.

C. Complete installation and startup checks according to manufacturer's written instructions and check for the following items:

1. No physical damage to unit.
2. Unit is level.
3. Chiller vibration isolation and flexible pipe connections are installed.
4. Clearances have been maintained and piping is installed for easy removal for service and tube cleaning.
5. Chilled and condenser water pipes have been connected to correct ports.
6. Labels and safety instructions are clearly visible.
7. Oil levels are as recommended by manufacturer.
8. Refrigerant charge is sufficient and chiller has been leak tested.

9. Shipping skids, blocks and straps are removed.
10. Refrigerant pressure relief is vented to outside.
11. Thermometers and pressure gauges are installed.
12. Controls and safety interlocks are installed and connected.
13. Pumps are installed, connected and operational.

D. Check and record performance of chiller protection devices.

E. Check and record performance of chilled and condenser water flow and low temperature interlocks.

F. Operate chiller for run in period as recommended by manufacturer.

G. Check static deflection of vibration isolators, including deflection during chiller startup and shutdown.

1. Check refrigerant charge. Check oil level.

3.7 CLEANING

A. After completion of system installation, start up, testing and prior to commissioning, completely and thoroughly clean up the chillers from any foreign material and construction dirt and dust.

END OF SECTION 23 64 11

SECTION 23 64 16 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
2. Packaged, portable refrigerant recovery units.
3. Heat-exchanger, brush-cleaning system.
4. Motor controllers.
5. Charge of refrigerant and oil.
6. Accessories.

B. This applies to chillers that are greater than or equal to 100 tons.

1.2 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. Boiler and Pressure Vessel Code, Section VIII, Division 1, “Rules for Construction of Pressure Vessels”.
2. Boiler and Pressure Vessel Code, Section IX, “Welding and Brazing Qualifications”.
3. B31.1, “Power Piping”.
4. B31.5, “Refrigeration Piping and Heat Transfer Components”.

B. Air-Conditioning and Refrigeration Institute (ARI):

1. Standard 550/590, “Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle”.
2. Standard 575, “Method of Measuring Machinery Sound Within an Equipment Space”.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. Standard 15, “Safety Standard for Refrigeration Systems”.
2. Standard 147, “Reducing the Release of Halogenated Refrigerants from Refrigerating and Air Conditioning Equipment and Systems”.
3. Standard 90.1, “Energy Standard for Buildings Except Low-Rise Residential Buildings”.

D. National Fire Protection Association (NFPA)

1. Standard 70, National Electrical Code (NEC)

E. American Gear Manufacturers Association (AGMA)

F. American National Standards Institute (ANSI)

G. American Society for Testing and Materials (ASTM)

H. Institute of Electrical and Electronics Engineers (IEEE)

I. National Electrical Manufacturers Association (NEMA)

J. Underwriters Laboratories (UL)

K. Occupational Safety & Health Act (OSHA) I International Building Code (IBC) 2009

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to California Building Code.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 40 deg F and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 55 deg F.
3. Performance Tolerance: Comply with the following in lieu of ARI 550/590:
    a. Allowable Capacity Tolerance: Zero percent.
    b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.
    c. Flow and temperature to follow ARI 550/590 Standards

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:
    a. Complete chiller including refrigerant and oil charge.
    b. Complete compressor and drive assembly including refrigerant and oil charge.
    c. Refrigerant and oil charge.
    d. Parts and labor including the refrigerant.
    e. Loss of refrigerant charge for any reason.

2. Warranty Period: Five (5) years.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of chiller.
5. Oil capacity of chiller.
6. Fluid capacity of evaporator, condenser, and heat-reclaim condenser.
7. Characteristics of safety relief valves.
8. Minimum entering condenser-fluid temperature.
9. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F increments.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Certificates: Provide certificate from manufacturer.

E. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control reports.

G. Startup service reports.

H. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals. Include start-up instructions, maintenance data, parts lists, controls, accessories, and troubleshooting guide.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. **Carrier.**

B. **Trane.**

C. **York.**

2.2 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, lubrication system evaporator, condenser, controls, interconnecting unit piping and wiring, and indicated accessories.

1. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.

2.3 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.

B. Compressor:

1. Casing: Cast iron, precision ground.

2. Impeller: High-strength cast aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.

C. Drive: Direct- or gear-drive, open or hermetic design using an electric motor as the driver.

1. Gear Drives: For chillers with gear drives, provide single or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards. Temperature rise of gears shall not exceed 70 deg F above ambient at full load.

2. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.

3. Seals: Seal drive assembly to prevent refrigerant leakage.

D. Compressor Motor:

1. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with open-dripproof enclosure.
5. Provide motor with thermistor or RTD in single motor winding to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide lifting lugs or eyebolts attached to motor.

E. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range. Operating speed shall be below the first critical speed.

1. Overspeed Test: 25 percent above design operating speed.

F. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

G. Economizers: For multistage chillers, provide interstage economizers.

H. Sound Attenuation: Compressors shall be provided with Sound Attenuation package to reduce to low frequency noise levels.

I. Capacity Control: Modulating, VFD and/or variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to 15 percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature.
4. Chillers with variable frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
5. Provide external electric guide-vane operator and linkage.
6. Seal points where guide-vane operating mechanism passes through the compressor casing to prevent refrigerant leakage.

J. Oil Lubrication System: Consisting of oil reservoir pump, filtration, cooler, factory-wired power connection, motor controllers and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating,

startup, cost down, and standby conditions including power failure.

2. Manufacturer's standard method to remove refrigerant from oil.
3. Oil filter shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
4. Refrigerant- or water-cooled oil cooler.
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.
8. Oil flow must be proven for compressor to run.
9. Oil pump shall be submerged in the oil reservoir to assure a positive oil supply.

2.4 REFRIGERATION

A. Refrigerant:

1. Type: R-134a; ASHRAE 34, Class A1.
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

D. Refrigerant Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system.

E. Refrigerant Isolation for Chillers Using R-134a: Factory install positive shutoff, manual isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell. Purge System:

1. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
2. Factory wire to chiller's main power supply and system complete with controls, piping and refrigerant valves to isolate the purge system from the chiller.
3. Construct components of non-corrodible materials.
4. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.

5. Efficiency of not more than 0.02 lb of refrigerant per pound of air when rated according to ARI 580.
6. Operation independent of chiller.

F. Positive-Pressure System:

1. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than 0.5 psig (adjustable) up to a pressure that remains within the vessel design pressure limits.
2. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

2.5 EVAPORATOR

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.

B. Shell Material: Carbon-steel rolled plates with seamless pipe.

C. Designed to prevent liquid refrigerant carryover from entering compressor.

D. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper.
4. Nominal OD: Per manufacturer.
5. Minimum Wall Thickness: Per manufacturer.
6. External Finish: Per manufacturer.
7. Internal Finish: Enhanced or smooth.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

H. Water Box:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type for water box with piping connections. Standard type for water box without piping connections.

3. Provide water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection. See FINISH later.

2.6 CONDENSER

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.

B. Shell Material: Carbon-steel rolled plates with seamless pipe.

C. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

D. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper.
4. Nominal OD: Per manufacturer.
5. Minimum Wall Thickness: Per manufacturer.
6. External Finish: Per manufacturer.
7. Internal Finish: Enhanced or smooth.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

H. Water Box:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type for water box with piping connections. Standard type for water box without piping connections.
3. Provide water boxes with lifting lugs or eyebolts.

4. Nozzle Pipe Connections: Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection. See FINISH later.

2.7 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   1. Thickness: 1-1/2 inches.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
   1. Apply adhesive to 100 percent of insulation contact surface.
   2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
   3. Seal seams and joints to provide a vapor barrier.
   4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
   5. Provide removable insulations covers for water boxes.

2.8 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect switch. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000 A.
   1. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker.
      a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   2. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
   3. Control-circuit transformer with primary and secondary side fuses.

C. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

D. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch length of liquid tight or flexible metallic conduit.

2.9 VARIABLE FREQUENCY CONTROLLER

A. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.

B. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.

C. Enclosure: Unit mounted, NEMA 250, Type 14X, with hinged full-front access door with lock and key.

D. General: Comply with the requirements of Division 26.

E. Integral Disconnecting Means: Door-interlocked, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000 A.

F. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.

G. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

1. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, AC line power to a fixed DC voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the AC line.
2. Regulator shall provide full digital control of frequency and voltage.
3. Inverter section shall change fixed dc voltage to variable-frequency, variable AC voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.

H. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

I. Operating Requirements:

1. Input AC Voltage Tolerance: 460-V AC, plus 10 percent or 506 V maximum.
2. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
3. Capable of driving full load, without derating, under the following conditions:
    a. Ambient Temperature: 0 to 50 deg C.
    b. Relative Humidity: Up to 90 percent (noncondensing).
    c. Altitude: sea level.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic

filter, 98 percent with harmonic filter.

6. Overload Capability: 1.05 times the full-load current for 7 seconds.
7. Starting Torque: As required by compressor-drive assembly.
8. Speed Regulation: Plus or minus 1 percent.
9. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
10. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
11. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

J. Internal Adjustability Capabilities:

1. Minimum Output Frequency: 6 Hz.
2. Maximum Output Frequency: 60 Hz.
3. Acceleration: 2 seconds to a minimum of 60 seconds.
4. Deceleration: 2 seconds to a minimum of 60 seconds.
5. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

K. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

1. Overtemperature.
2. Short circuit at controller output.
3. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
4. Open circuit at controller output.
5. Input undervoltage.
6. Input overvoltage.
7. Loss of input phase.
8. Reverse phase.
9. AC line switching transients.
10. Instantaneous overload, line to line or line to ground.
11. Sustained overload exceeding 100 percent of controller rated current.
12. Starting a rotating motor.

L. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

M. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

N. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.
7. Motor speed (percent).
8. Fault or alarm status (code).
9. DC-link voltage.
10. Motor output voltage.
11. Input kilovolt amperes.
12. Total power factor.
13. Input kilowatts.
14. Input kilowatt-hours.
15. Three-phase input voltage.
16. Three-phase output voltage.
17. Three-phase input current.
18. Three-phase output current.
19. Three-phase input voltage total harmonic distortion.
20. Three-phase input current total harmonic distortion.
21. Output frequency (Hertz).
22. Elapsed operating time (hours).
23. Diagnostic and service parameters.

O. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

P. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.

Q. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.

R. Cooling: Air, refrigerant, or water cooled.

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

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

T. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

2.10 COATING

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with a total dry film thickness of at least 4 mils.
2. Provide baked phenolic coating finish with a total dry film thickness of at least 6 mils.
3. Paint surfaces that are to be insulated before applying the insulation.
4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat to be manufacturer's standard.

2.11 ACCESSORIES

A. Flow Switches:

1. Chiller manufacturer shall furnish a switch for each evaporator and condenser and verify field mounting location before installation.
2. Pressure Differential Switches:
   a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
   b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
   c. Set Point: Screw type, field adjustable.
   d. Electrical Connections: Internally mounted screw-type terminal blocks.
   e. Switch Enclosure: NEMA 250, Type 4.
   f. Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.

B. Chillers shall be provided with BACNet Controls including BACNet interface communication card. The Control panel shall provide mapping out all points, and the Chiller manufacturer shall allow enough time to assist the Control Company to map all the chiller points.

C. Sound Barrier:

1. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
2. Provide for repeated installation and removal without use of tape or calk.

3. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
4. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
5. Form covers around control devices, gauges, conduit, piping, and supports without degrading sound-barrier performance.
6. Continuously lap all exposed seams at least 2 inches for better sound containment.
7. Permanently label each section of cover to indicate its location, description, size, and number sequence.
8. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

D. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to LAWA service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

E. Quick Start B with Uninterruptible Power Supply (UPS)

1. Quick Start shall enable the chiller to restart in 15 seconds the power is restored. Quick Start minimizes the time to restart and loads the chiller as quickly as possible, to rapidly achieve the leaving chiller water temperature setpoint. The main objective is to provide minimum down time and the fastest restart/loading as possible. Once the chiller is running and close to setpoint, it will return to standard chiller YK control

2.12 SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

B. Factory performance test chillers, before shipping, according to ARI 550/590.

1. Test the following conditions:
   a. Design conditions indicated.
   b. Reduction in capacity from design to minimum load in steps of 10 with condenser fluid at design conditions.
2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

C. For chillers using R-134a refrigerant, factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. For chillers located indoors, rate sound power level according to ARI 575.

PART 3 - EXECUTION

3.1 GENERAL

A. The chillers will be delivered to the designated rigger's yard. Contractor shall coordinate shipment, receive, inspect and accept responsibility for equipment. Any damage or deficiency shall be resolved by Contractor directly with manufacturer and/or hauler, with no recourse to the LAWA.

B. Delivery and rigging of chillers will be staged based on the construction schedule. Contractor shall protect equipment, transport to the site, rig into place, install, pipe, wire and test equipment in accordance with drawings, specifications and manufacturer's recommendations. Contractor shall coordinate any requirements directly with the manufacturer.

C. Consult equipment supplier regarding rigging requirements. If disassembly is required, both disassembly and reassembly shall be done by the Contractor in strict compliance with the manufacturer's instructions, under supervision of chiller manufacturer's representative, and shall not void any warranties.

3.2 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Determine exact locations before roughing-in for piping and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 CHILLER INSTALLATION

A. Equipment Mounting: Install chiller on concrete bases using restrained spring isolators if required.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Charge chiller with refrigerant and fill with oil if not factory installed.

D. Install separate devices furnished by manufacturer and not factory installed.

E. Install piping adjacent to chiller to allow service and maintenance.

F. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, thermometer,

and plugged tee with pressure gauge. Connect to evaporator outlet with shutoff valve, balancing valve, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, and drain connection with valve. Make connections to chiller with a mechanical coupling.

G. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, thermometer, and plugged tee with pressure gauge. Connect to condenser outlet with shutoff valve, balancing valve, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, and drain connection with valve. Make connections to chiller with a mechanical coupling.

H. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping to the outdoors without valves or restrictions. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

I. For chillers equipped with a purge system, extend purge vent piping to the outdoors.

J. Miscellaneous Unit Water Piping: Provide a water supply manifold piped to the compressor oil cooler and the unit-mounted refrigerant recovery unit condenser. The supply manifold shall be complete and include valves, sight glasses, thermometers and other devices to verify sufficient water flow.

K. Miscellaneous Unit Refrigerant Piping: Provide all interconnecting refrigerant piping between the chiller, refrigerant recovery unit, compressor and condenser, and remote refrigerant storage vessel, if required.

L. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gauges are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. Verify that refrigerant pressure relief device is vented outside.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.

12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.5 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Train LAWA Maintenance personnel to adjust, operate, and maintain chillers.

C. Provide minimum 12 hours (3 shifts total) of classroom and hands on training to LAWA Maintenance personnel.

3.6 FACTORY PERFORMANCE TESTS

A. Manufacturer shall conduct factory performance test for each chiller in accordance with ARI 550/590, to verify design capacity and part load capacity points indicated on Bid form. LAWA and/or LAWA's representative (2 persons) may elect to witness tests. Notify LAWA and/or LAWAs representative of test date at least 2 weeks in advanced. There will be zero tolerance on capacity and NPLV, other parameters are per ARI 550/590 tolerance.

B. Before shipment of chillers, all records and certifications approving testing requirements shall be submitted to and approved by LAWA.

C. Defective work or material shall be replaced or repaired, as necessary, and inspection and test repeated. Repairs shall be made with new materials. Run new performance test in accordance with ARI standard.

D. If chiller assembly fails to meet design capacity and a minimum of 15% more capacity at lower condenser water temperature, LAWA may elect not to accept delivery until chiller is modified at manufacturer's expense to meet design capacity.

E. If chiller assembly fails to meet any of part load performance data supplied by manufacturer with his bid, LAWA may elect not to accept delivery until chiller is modified at manufacturer's expense to meet all of design and part load performance data or to assess penalty charge equal to 10 years operating cost differential. This differential is to be determined by using part load data included in bid form and data obtained from performance test, subtracting bid data annual operating cost from test data annual operating cost, and multiplying difference by ten. Penalty charge shall apply to all chillers.

F. All design conditions and part load performance data shall be evaluated with 480 volt, 3-phase, 60 hertz power supplied to chiller.

G. Conduct test at approved ARI certified test facility of the manufacturer.

H. Instrumentation used for testing must be calibrated within 6 months of test date and traceable to National Bureau of Standards. Documentation verifying NBS traceability shall be

submitted to LAWA.

1. Performance test shall be two-point test for one chiller. Points will be selected at time of test. Points will be selected from submitted performance from 25 to 100% of capacity.

3.7 COMMISSIONING

A. The manufacturer shall be present during all commissioning events. The anticipated schedule is for commissioning to occur during the last six to eight weeks during construction just prior to the anticipated end of construction. Include 40 hours of field time to perform the commissioning requirements.

B. A factory-authorized representative shall perform the startup service.

1. Fill out startup checklists and attach copy with Contractor Startup Report.

C. Complete installation and startup checks according to manufacturer's written instructions and check for the following items:

1. No physical damage to unit.
2. Unit is level.
3. Chiller vibration isolation and flexible pipe connections are installed.
4. Clearances have been maintained and piping is installed for easy removal for service and tube cleaning.
5. Chilled and condenser water pipes have been connected to correct ports.
6. Labels and safety instructions are clearly visible.
7. Oil levels are as recommended by manufacturer.
8. Refrigerant charge is sufficient and chiller has been leak tested.
9. Shipping skids, blocks and straps are removed.
10. Refrigerant pressure relief is vented to outside.
11. Thermometers and pressure gauges are installed.
12. Controls and safety interlocks are installed and connected.
13. Pumps are installed, connected and operational.

D. Check and record performance of chiller protection devices.

E. Check and record performance of chilled and condenser water flow and low temperature interlocks.

F. Operate chiller for run-in period as recommended by manufacturer.

G. Check static deflection of vibration isolators, including deflection during chiller startup and shutdown.

1. Check refrigerant charge. Check oil level.

3.8 CLEANING

A. After completion of system installation, start-up, testing and prior to commissioning, completely and thoroughly clean up the chillers from any foreign material and construction dirt and dust.

END OF SECTION 23 64 16

SECTION 23 65 00 - COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Open-circuit, induced-draft, counterflow cooling towers.
2. Basin water level controls.
3. Closed circuit fluid coolers and/or condensers are also acceptable, subject to meeting the capacity requirements.

B. Cooling towers are specified herein for reference only and will be for temporary use.

C. Cooling tower shall operate in a manner that no visible plume is produced. If necessary provide gas fired heaters or HW coils for cooling tower discharge for plume abatement.

1.2 REFERENCES

A. American Society of Mechanical Engineers (ASME).

1. Boiler and Pressure Vessel Code, Section VIII, Division 1, “Rules for Construction of Pressure Vessels”.
2. Performance Test Code PTC 23, “Atmospheric Water Cooling Equipment”.

B. Cooling Technology Institute (CTI).

C. Standard 201, “Standard for the Certification of Water-Cooling Tower Thermal Performance”.

D. Acceptance Test Code ATC 105, “Acceptance Test Code for Water Cooling Towers”.

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

E. Standard 90.1, “Energy Standard for Building Except Low-Rise Residential Buildings”.

1. National Fire Protection Association (NFPA).

F. Standard 70, “National Electrical Code”.

1. American National Standards Institute (ANSI).
2. American Society for Testing and Materials (ASTM).
3. Institute of Electrical and Electronics Engineers (IEEE).
4. National Electrical Manufacturers Association (NEMA).

G. Factory Mutual (FM).

H. Underwriters Laboratories (UL).

1.3 SUBMITTALS

A. Product Data: Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, materials of construction, furnished specialties, and accessories.

1. Maximum flow rate.
2. Minimum flow rate.
3. Drift loss as percent of design flow rate.
4. Volume of water in suspension for purposes of sizing a remote storage tank.
5. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
6. Performance curves for the following:
   a. Varying entering-water temperatures from design to minimum.
   b. Varying ambient wet-bulb temperatures from design to minimum.
   c. Varying water flow rates from design to minimum.
   d. Varying fan operation (off, minimum, and design speed).
7. Fan airflow, brake horsepower, and drive losses.
8. Pump flow rate, head, brake horsepower, and efficiency.
9. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
10. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Sizes and locations of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

D. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

E. Certificates: Provide certificate from manufacturer.

F. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Source quality-control reports.

H. Field quality-control reports.

I. Startup service reports.

J. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals. Include start-up instructions, maintenance data, parts lists, controls, accessories, and trouble-shooting guide.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:

1. Fan assembly including fan, drive, and motor.
2. All components of cooling tower.
3. Warranty Period: Five (5) years.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit start-up instructions, maintenance data, parts lists, controls, and accessories.

PART 2 - PRODUCTS

2.1 OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. Manufacturers: Subject to compliance with requirements, provide one of the following:
   1. **Baltimore Aircoil Company.**
   2. **Delta Cooling Towers.**
   3. **Evapco.**

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of 30 lbf/sq. ft.

D. Casing and Frame:
   1. Casing and Frame Material: Stainless steel, Type 304.

E. Collection Basin:
   1. Material: Stainless steel, Type 304.
   2. Strainer: Removable stainless-steel strainer with openings smaller than nozzle orifices.
   3. Overflow and drain connections.
   4. Makeup water connection.
   5. Outlet Connection: ASME B16.5, Class 150 flange.
   6. Removable equalization flume plate between adjacent cells of multiple-cell towers.
   7. Equalizer connection for field-installed equalizer piping.
   8. Basin Sweeper Distribution Piping and Nozzles:
      a. Pipe Material: PVC.
      b. Nozzle Material: Plastic.
      c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

F. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
   1. Enclosure: NEMA 250, Type 4.
   2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level.
   3. Electrode Probes: Stainless steel.
   4. Water Stilling Chamber: Corrosion-resistant material.

5. Solenoid Valve: Slow closing with stainless-steel body; controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120V, single phase, 60 Hz.

G. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: PVC.
2. Spray Nozzle Material: PVC.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

H. Fill:

1. Materials: PVC, resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 according to ASTM E 84.
2. Minimum Thickness: 15 mils before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.

I. Removable Drift Eliminator:

1. Material: Fiberglass reinforced plastic; resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

J. Air-Intake Louvers:

1. Material: Matching casing.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

K. Removable Air-Intake Screens: Stainless-steel wire mesh.

L. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum.
2. Hub Material: Aluminum.
3. Blade Pitch: Field adjustable.

4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 50,000 hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

M. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    a. Belt: Multiple V-belt design with a matched set of cogged belts.
    b. Belt: One-piece, multigrooved, solid-back belt.
    c. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    d. Belt-Drive Guard: Comply with OSHA regulations.

N. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

O. Fan Motor:

1. Motor Enclosure: Totally enclosed fan cooled (TEFC).
2. Service Factor: 1.15.
3. Insulation: Class F.
4. Variable-Speed Motors.

P. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Stainless-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Stainless-steel bar grating.
    a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall

be elevated so that all parts are above the high water level of the collection basin.

b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

B. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Maintain manufacturer's recommended clearances for service and maintenance.

B. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.2 CONNECTIONS

A. Install piping adjacent to cooling towers to allow service and maintenance.

B. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

C. Provide drain piping with valve at cooling tower drain connections and at low points in piping.

D. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

E. Domestic Water Piping: Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.

F. Supply and Return Piping: Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union, flange, or mechanical coupling.

G. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform field tests and inspections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections: Comply with ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment."

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Clean entire unit including basins.

b. Verify that accessories are properly installed.

c. Verify clearances for airflow and for cooling tower servicing.

d. Check for vibration isolation and structural support.

e. Lubricate bearings.

f. Verify fan rotation for correct direction and for vibration or binding and correct problems.

g. Adjust belts to proper alignment and tension.

h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.

i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.

j. Check vibration switch setting. Verify operation.

k. Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.

l. Verify operation of basin heater and control.

m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.

n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.5 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.6 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Engage a factory-authorized service representative to train LAWA's maintenance personnel to adjust, operate, and maintain cooling towers.

C. Training to include minimum of 15 personnel for 40 hours training, 16 hours shall be classroom training and 24 hours shall be hands-on training.

END OF SECTION 23 65 00

SECTION 23 74 13 - CENTRAL-STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes modular factory fabricated air handling units (AHU) and accessories for indoor and outdoor installation.

1.2 REFERENCES

A. American Bearing Manufacturers Association:

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:

1. AMCA 99 - Standards Handbook.
2. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
3. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
4. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
5. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

C. Air-Conditioning and Refrigeration Institute:

1. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
2. ARI 430 - Central-Station Air Handling Units.
3. ARI Guideline D - Application and Installation of Central Station Air Handling Units.

D. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.

E. Sheet Metal and Air Conditioning Contractors:

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

F. Underwriters Laboratories Inc.:

1. UL 900 - Air Filter Units.
2. UL - Fire Resistance Directory.

G. NRCA standards.

1.3 SUBMITTALS

A. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

B. Product Data, Submit the following:

1. Published Literature: Indicate capacities, ratings, gauges and finishes of materials, and electrical characteristics and connection requirements.
2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
3. Fans: Performance and fan curves with specified operating point plotted, power, RPM. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
4. Dampers: Include leakage, pressure drop, and sample calibration curves. Indicate materials, construction, dimensions, and installation details.
5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring. Indicate factory installed and field installed wiring.
6. Clearly identify the type of Coating(s) being proposed for use.

C. Manufacturer's Installation Instructions.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.5 QUALITY ASSURANCE

A. All items shall be in accordance with the requirements dictated by the City of Los Angeles Department of Building and Safety, and LAWA standards.

1.6 WARRANTY

A. Furnish five year manufacturer warranty for Central Station Air Handling Units and drives.

B. Parts warranty to be provided by manufacturer and labor warranty to be provided by the installing contractor.

C. The Air Handling Unit manufacturer shall provide single source responsibility for all components of the unit whether specifically manufactured or purchased outside.

D. All major components used to assemble the air-handling unit, with the exception of electrical devices, control dampers, VFD drives, bearings, and controls, shall be manufactured by the unit supplier. Primary fans and coils not manufactured by the air handling unit manufacturer as a single source responsibility are not acceptable.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNITS

A. Manufacturers:

1. **Temtrol.**
2. **Energy Labs.**
3. **Governair**

B. Performance Base: Sea level.

C. Roof Curbs: Required.

1. Factory assembled galvanized steel mounting curb designed and manufactured by unit manufacturer is required for all rooftop installations.
2. Perimeter type with support of air handling sections.
3. Furnish supply and return opening duct frames as part of curb structure allowing duct connections to be made directly to curb.
4. Minimum of 12 inches high.
5. Furnish gaskets for field mounting.

D. Interior Curb: Required

1. Minimum 4 inch high concrete housekeeping pad is required for interior installations.

2.2 CASING

A. Frame :

1. Channel base of welded steel. Assemble sections with gaskets and bolts.

B. Outside Casing:

1. Galvanized Steel: 0.0635 inch (16 gauge).
2. Seal fixed joints with flexible weather tight sealer. Seal removable joints with closed-cell foam gasket.
3. Furnish cap strips over roof flanges.
4. Furnish rain caps and gaskets on access doors.

C. Outside Casing Finish:

1. Exterior panels with 6 mils dry of self-priming semi-gloss high solids polyurethane paint over 2 mils of the epoxy primer and seal and 2 mils of the etching primer for a total of 10 mils.
2. Coating shall withstand 5,000 hour of salt spray test in accordance with ASTM B117.
3. Color: As selected by LAWA.

D. Inside Casing:

1. 316 Stainless Steel: Perforated 0.0375 inch thick (20 gauge) at fan section.
2. 316 Stainless Steel: Solid, 0.0375 inch thick (20 gauge) at filter and coil section.
3. Floor Plate: 316 Stainless Steel: continuously welded 0.0785 inch thick (14 gauge) at inner floor. Galvanized Steel: 0.0396 inch thick (20 gauge) at bottom floor.
4. Insulation: Neoprene coated, glass fiber, applied to internal surfaces with adhesive and weld pins with exposed edges of insulation coated with adhesive.‘K’ factor at 75 degrees F: Maximum 0.26 Btuh inch/ sq ft/ degrees F.Density: 4 inch thick, 3lbs/cu ft.

5. Inspection Doors: 8 x 12 inch of galvanized steel for flush mounting, with gasket, latch, and handle assembly and 1/4 inch thick Plexiglas inspection window.

E. Walk-in Access Doors:

1. 24 x 60 inch galvanized steel exterior and 316 stainless steel interior insulated sandwich construction, for flush mounting, with hinges, gasket, latch, and handle assemblies, and 8 x 12 inch inspection window with 1/4 inch thick Plexiglas.

F. Lights:

1. Located in accessible sections suitable for damp locations with wire guards, factory wired to weatherproof switch and pilot light and duplex outlet mounted on casing exterior.

G. Drain Pans

1. Double thickness 316 stainless steel with insulation between layers with welded corners. Cross break and pitch to drain connection. Furnish drain pans under mixing section cooling coil section. For units with multiple coils, provide drain pans for each coil section.

H. Bottom Inlet Units:

1. Furnish stainless steel walking grate on structural supports.

I. Strength:

1. Furnish structure to brace casings for suction pressure of 1/240 of longest plane being measured at design static pressure or a maximum of 10 in. WG.

J. Louvers:

1. Stationary, galvanized steel construction, 4 inch deep with plenum, nylon bearings, 1/2 inch mesh, 0.04 inch stainless steel wire bird screen in stainless steel frame, and tested and rated per AMCA 500.

2.3 PLENUM FANS (systems less than 15,000 CFM)

A. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

C. Mounting: Fan and motor shall be mounted on an internal, fully welded, rigid steel assembly. Each individual fan assembly shall be free-floating at all four corners on minimum 2" deflection spring type isolators with earthquake restraints. The spring isolators shall be mounted to structural steel members and shall be rated for a minimum of 1.0g, unless the Structural Engineer of Record of the building provides a higher rating. The fan discharge shall be isolated from the cabinet by means of a neoprene-coated flexible connection.

D. Fan Modulation: Variable Frequency Drive. See Section 23 81 07 VARIABLE FREQUENCY DRIVES.

E. Flexible Connection: Separate unit from connecting ductwork.

2.4 FAN ARRAYS (systems over 15,000 CFM)

A. Fan array system shall include multiple, direct driven, Arrangement #4 plenum fans, constructed per AMCA requirements for the duty specified class III as required. Class I and Class II fans are not acceptable.

B. The array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit to equal the specified cooling coil and/or filter bank face velocity by +/- 10% when measured at a point 36" from the intake side of the fan array intake plenum wall, and at a distance of 72" from the discharge side of the fan array intake plenum wall.

C. Fans shall be rated in accordance with and certified by AMCA for performance. All fans shall be selected to deliver the specified airflow quantities at the specified operating Total Static Pressure and specified fan motor speed. The fan array shall be selected to operate at system Total Static Pressure that does not exceed 90% of the specified fan peak static pressure flow capacity.

D. Each fan/motor cube or cell shall include a minimum 10 gauge, G-90 galvanized steel intake wall,0.100 inch aluminum spun fan inlet funnel and 10 gauge G-90 galvanized steel motor support rail structure.

E. All motors shall be standard foot mounted type TEAO selected at the specified operating voltage, RPM, and efficiency as specified or scheduled elsewhere. Motors shall meet the requirements of NEMA MG-1 Part 30, 31, section 4.4.2.

F. Motors shall be as manufactured by Baldor, Siemens or Tashibe for use in multiple fan arrays that operate at varying synchronous speed as driven by appropriate VFD.

G. Each individual cube or cell in the multiple fan arrays shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan or multiple fans become disabled.

H. The system effect for the back flow prevention device shall be included in the criteria for the TSP determination for fan selection purposes, and shall be indicated as a separate line item SP loss in the submittals. Motorized dampers for these purposes are not acceptable.

I. Each fan motor shall be individually wired to the common control panel. Each VFD shall be sized for total connected HP for all fan motor connected. Wire sizing shall be determined and installed in accordance with applicable NEC standards and local code requirements.

J. All motors in the fan array shall be provided with individual Motor Circuit Protector for overload protection. The Motor Circuit Protector shall be located in the starting device enclosure or, if called by design, in the separate enclosure located as close as possible to the fan array.

K. Provide remote status monitoring of the individual fan status by the auxiliary contacts wires in series. Provide individual status light for each fan.

L. Each fan array assembly shall be equipped with the a factory supplied air flow monitoring station with two static pressure taps and two total pressure taps located in the throat of each fan inlet cone. The flow monitoring station shall not obstruct the inlet of the fan and shall have no effect on the fan performance or the sound power level.

M. Each fan array cube or cell shall be provided with the airflow totalizing station that sums up each cell airflows and sends a total airflow data as a single point to the BAS. Airflow Totalizer station by one of the following manufacturers shall be provided, mounted externally on the AHU: Paragon FAATS, Nortek Totalizer and Ebton GTx.

N. Sensing modules shall be NEMA 4 rated and house up to eight transformers. Multiple sensing modules shall be used for the fan array with more than eight fans. Station shall not obstruct the inlet to the fan and shall have no effect on the fans performance or on the sound power levels.

O. Sensing modules enclosure shall be NEMA 4 rated and house up to 8 transmitters. Multiple sensing modules shall be used in the fan array with more than 8 fans.

P. Polyethylene tubing shall be used to connect pressure tabs to the sensing modules located inside the fan section. No pneumatic tubing shall be installed outside of the air-handling unit. CAT-5 cable shall be used to connect the sensing unit inside the AHU to the airflow totalizing panel outside of the AHU.

Q. Airflow Totalizer Panel shall display total CFM reading for one or both fan arrays in the AHU and shall be connected to the BAS.

2.5 BEARINGS AND DRIVES (DIRECT DRIVE FANS)

A. Single or multiple, Arrangement #4 plenum fan assemblies shall be provided. Fans shall be arranged to provide even air distribution within the unit cabinet. Minimum/maximum fan quantity shall be as indicated in the project documents. Total fan BHP and motor HP shall not be exceeded ones indicated in the project documents. Motor efficiencies indicated in the projects documents are considered to be the minimum allowed.

B. Bearings: Pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-50 life at 100,000 hours or roller bearings, or ABMA 11, L-50 life at 400,000 hours.

C. Individual fan performance shall be based on tests run in an AMCA certified laboratory and administered in accordance with AMCA Standards 210 and 300. Fans shall be licensed to bear the AMCA seal for air and sound performance. Submitted fan performance shall be adjusted to reflect multiple fans running inside the cabinet and to reflect any affects from the unit cabinet and other internal components. Fans shall be minimum Class 2 construction.

D. The fan wheel shall be aluminum with extruded aluminum airfoil blades continuously welded to the fan side plates. The fan back plane shall be bolted to a cast aluminum fan hub with keyway. Fans not using airfoil blades, or using steel construction, will not be considered. Fan inlets shall be isolated from the cabinet by means of a neoprene-coated flexible connection.

E. Motors shall be premium efficiency to meet or exceed the requirements in EISA 2007. Motors shall be TEFC, NEMA frame, cast iron casing, ball bearing type complete with grease lubricated bearings and zerk fittings for field lubrication. Motors shall have a NEMA Class F insulation rating with Class B temperature rise, and have a 1.15 service factor. BHP values as shown on the Schedule are considered the maximum allowable.

F. Fans shall be provided with thrust restraints.

G. Each motor shall be provided with a shaft grounding device that will bleed potential induced motor shaft voltage to ground.

2.6 COILS

A. Casing with access to both sides of coils. Enclose coils with headers and return bends fully contained within casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

B. Drain Pans: Sized per ARI guidelines and as shown in the plan drawings downstream of coil and downspouts for cooling coil banks more than one coil high.

C. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.

D. Fabrication:

1. Water Coils Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
2. Refrigerant Coils Tubes: 3/8 inch OD seamless copper expanded into fins, brazed joints. Fins: 0.008" Copper.
3. Casing: Die formed channel frame of 316 stainless steel.
4. All coils shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall meet or exceed a class 5B result on a Cross Hatch Adhesion Test (ASTM D3359). Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray (ASTM G85) test. Finned-tube coils applied coating shall have 5 year warranty.
5. Provide five (5) year warranty for all coils.

E. Water Cooling and Heating Coils:

1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.

F. Refrigerant Coils:

1. Headers: Seamless copper tubes with silver brazed joints.
2. Liquid Distributors: Brass or copper Venturi distributor with seamless copper distributor tubes.

G. Configuration: Down feed with bottom suction.

2.7 FILTRATION SYSTEMS

A. Various filter types are specified in HVAC AIR CLEANING DEVICES, Section 23 40 00.

B. Ultra Violet Germicidal Irradiation (UVGI) system, Section 23 42 00.

C. Photocatalytic Oxidation (PCO) system, Section 23 41 00.

2.8 DAMPERS

A. Mixing Boxes: Section with factory mounted outside and return air dampers of ultra-low leak extruded 6063T5 aluminum airfoil blades with dual durometer bulb type edge seals and stainless steel arc end seals in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in opposed blade arrangement

B. Outside Air Damper Leakage: Shall not exceed 6 CFM/ft^2 at 5.0" of static pressure. Leakage rating shall be determined by testing performed in accordance with AMCA Standard 500, figure 5.5, and tests shall have been performed by an independent testing laboratory.

C. Damper Leakage: Shall not exceed 6 CFM/ft^2 at 5.0" of static pressure. Leakage rating shall be determined by testing performed in accordance with AMCA Standard 500, figure 5.5, and tests shall have been performed by an independent testing laboratory.

D. Damper Actuators: Furnish factory installed electric damper actuators for outside air, return air and exhaust air dampers.

2.9 OUTSIDE AIR MEASURING AND MODULATION DEVICE

A. Factory mounted thermal dispersion type Airflow Measurement Device (AMD) for the outside air, return air and supply air.

B. Damper and airflow measurement assembly sized to accommodate economizer outside airflow.

C. Performance Data:

1. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 5,000 FPM (25.4 m/s).

D. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range. Each sensing node shall have a temperature accuracy of ±0.15° F (0.1° C) over an operating range of -20° F to 160° F. (-28.9° C to 71° C).

2.10 CONTROLS

A. All Central Station Air Handling Units shall be equipped with the unit controller capable to be integrated into the Building Automation System (BAS). Refer to Section 25 20 00 of the Guide Specifications.

B. Factory installed controls conduit and junction boxes.

C. Control devices provided and installed by the controls contractor in the field.

2.11 ELECTRICAL

A. Motor:

1. Inverter duty, NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
2. Enclosure Type: Totally enclosed, fan cooled.

3. Motors must be "matched" with variable frequency drives.
4. Provide shaft grounding device that will bleed potential induced motor shaft voltage to ground.

B. Electrical Requirements:

1. Where unit-mounted disconnects are provided, mount disconnect switches on the exterior of the unit.
2. Variable Frequency Controllers shall be factory mounted in a ventilated compartment that is part of the air-handling unit and factory wired to motors and controls. Access shall be through a louvered access door.

2.12 FACTORY TESTING

A. The following testing shall be provided on a minimum of three units. LAWA shall select the three units to be tested. **Manufacturer shall include cost of travel to allow two LAWA representatives to witness all factory tests.** Manufacturer shall provide a written report of all test results to the Contractor and LAWA as part of the shop drawing process. In the event that tested units do not meet performance requirements (Including but limited to leak, deflections, air volume and sound), manufacturer shall provide enhancements, within the requirements of this specification, until unit meets testing requirements. In the event that two or more units do not meet performance requirements, LAWA shall select an additional three units for testing – and the above requirements shall be applicable to newly tested units.

B. Factory Leak Test

1. Factory test shall verify that unit casing leakage is less than 0.5% of design airflow or 100 CFM whichever is greater at 1 ½ times design static pressure or a maximum of 10 in. WG. Unit openings shall be sealed. A pressure blower shall be connected to the Air Handling unit and adjusted to provide the test pressure. At the manufacturer's option, the unit shall be either positively or negatively pressurized. CFM shall be measured using a calibrated orifice. The measured CFM shall be considered casing leakage. Casing leakage must not exceed 0.5% of design CFM.

C. Factory Cabinet Deflection Test:

1. Air handling unit manufacturer shall provide Panel Deflection Test on units in conjunction with the Casing Leakage Test. Panel deflection test shall verify casing deflection is less than 1/240 of longest plane being measured at design static pressure or a maximum of 10 in. WG. The casing deflection shall be measured at midpoint of panel and at panel seam.

D. Factory Air Performance Test:

1. Air handling unit manufacturer shall test at an AMCA Accredited Laboratory for air performance per AMCA Standard 210. For air handling units with air volumes below 65000 CFM, air volume shall be determined using a multiple nozzle chamber that meets the requirements of AMCA 210 (Laboratory Methods for Performance Testing) figure 12 or 15. Measured air volume, static pressure, and RPM shall be shall be within the tolerance limits of AMCA Standard 211 (Certified Ratings Program Air Performance).

E. Factory Sound & Air Performance Test:

1. Air handling unit manufacturer shall test a minimum of three units at an AMCA Accredited Laboratory for airflow testing in accordance with AMCA Standard 210 and sound testing in accordance with AMCA Standard 300. Specified air volume shall first be confirmed in accordance with AMCA standard 210 (Laboratory Methods of Testing Fans for Performance Rating). Air Volume, static pressure, and RPM shall be within the tolerance limits of AMCA Standard 211 (Certified Ratings Program Air Performance).

2. Once design operating point has been confirmed, the submitted sound power levels for both inlet and outlet shall be measured per AMCA Standard 300 (Reverberant Room Method for Testing of Fans) and the relevant parts of ARI Standard 260 (Sound Rating of Ducted Air Moving and Conditioning Equipment). The total air handling unit volume shall not exceed 5% of the volume of the reverberant room. The reverberant room used for testing shall be qualified to perform narrow band measurements in accordance with AMCA Standard 300 Appendix B. All measurements shall be taken in 1/3 octave bands. If applicable, duct end correction and elbow corrections shall be calculated per ARI Standard 260. The test results will verify that inlet and outlet sound power levels are within the tolerance limits of AMCA-311 (Certified Sound Ratings Program) of the specified levels.

3. Sound power data shall be given at the supply connection(s) and return connection(s) in addition to radiated sound power from the cabinet. Raw fan sound power data shall be derived from tests done on the same sizes and types of fans scheduled. Data extrapolated from non-like fan sizes and types scheduled, is not acceptable. Attenuation assumed for cabinet configuration, type of insulation, opening locations, and sizes, etc., shall be verified through actual test measurements. Alternate equivalent method of testing will not be accepted.

4. Factory testing not required for knockdown construction air handling units. Contractor is responsible for sound and performance field-testing of the knockdown construction air-handling units.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible connections between AHU discharge and ductwork.

B. Install condensate piping with trap and route from drain pan to nearest code approved receptacle via gravity flow and terminate with an air gap as required by Code.

C. Insulate exposed section of the coils as specified for piping.

3.2 INSTALLATION CHILLED WATER COOLING COIL

A. Make connections to coils with unions or flanges.

B. Connect water supply to leaving airside of coil (counter flow arrangement).

C. Locate water supply at bottom of supply header and return water connection at top.

D. Install water coils to allow draining and install drain connection at low points.

E. Install the following piping accessories on chilled water piping connections.

1. On supply:

a. Thermometer well and thermometer.
b. Well for control system temperature sensor.
c. Shutoff valve.
d. Strainer.
e. Control valve.
f. Pressure gage.

2. On return:

a. Thermometer well and thermometer.
b. Well for control system temperature sensor.
c. Pressure gage.
d. Shutoff valve.
e. Balancing valve or Flow control valve.

3.3 INSTALLATION HOT WATER HEATING COIL

A. Same as for chilled water coil.

3.4 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Furnish services of factory trained representative for minimum of one day to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, calibrate controls, and instruct LAWA on operation and maintenance

C. Training to include minimum of eight LAWA personnel for 40 hours training, 16 hours shall be classroom training per person and 24 hours shall be hands-on field training per person.

3.5 STORAGE AND CLEANING

A. Unit is to be cleaned and bagged with a fiber reinforced heavy duty, heat shrink shipping bag. The bottom of the bag shall be provided with a rope hem and ratchet assembly that shall be used to close the bag around the perimeter of the base tube. Commercial style desiccant bags shall be included in each unit to help absorb moisture during transit. Units shall be clearly labeled on the unit exterior of the bags indicating the contents

B. Vacuum clean coils and inside of unit cabinet after the installation and connection to the air distribution system.

C. Install temporary filters during construction period. Replace with permanent filters at Substantial Completion.

3.6 PROTECTION OF FINISHED WORK

A. Do not operate units until units and ductwork are clean, filters are in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION 23 74 13

SECTION 23 81 03 - PACKAGED ROOFTOP AIR CONDITIONING UNITS – NON-CUSTOM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged rooftop air conditioning unit (5 tons and smaller).
2. Roof curb.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.3 SUBMITTALS

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.
3. Weights.
4. Rough-in connections and connection requirements.
5. Duct connections.
6. Electrical requirements with electrical characteristics and connection requirements.
7. Controls.
8. Accessories.

B. Test Reports: Submit results of factory test at time of unit shipment.

C. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

E. Manufacturer’s Field Reports: Submit start-up report for each unit.

1.4 WARRANTY

A. Furnish five year manufacturer's warranty for compressors, heat exchangers and condenser coils.

1.5 MAINTENANCE SERVICE

A. Furnish service and maintenance of equipment for one year from Date of Substantial Completion. Include maintenance items as shown in manufacturer's operating and maintenance data, including filter replacements, fan belt replacement, and controls checkout and adjustments.

B. Furnish 24-hour emergency service on breakdowns and malfunctions for this maintenance period.

PART 2 - PRODUCTS

2.1 ROOFTOP AIR CONDITIONING UNITS

A. Manufacturers:

1. **Carrier**
2. **Trane**
3. **York**

B. Product Description: Self-contained, packaged, factory assembled and wired, consisting of roof curb, cabinet, supply fan, refrigerant cooling coil, compressor, refrigeration circuit, condenser, gas-fired heating section, air filters, mixed air casing, controls, and accessories.

C. Roof Mounting Curb: 14 inch high, galvanized steel, channel frame with gaskets, nailer strips. Full perimeter type for mounting under entire unit.

D. Cabinet:

1. Designed for outdoor installation with weatherproof construction.
2. Panels: Constructed of galvanized steel with baked enamel finish meeting salt spray test in accordance with ASTM B117. Furnish access doors or removable access panels.
3. Insulation: Factory applied to exposed vertical and horizontal panels. Minimum one inch thick neoprene coated glass fiber with edges protected from erosion.

E. Supply Fan: Forward curved centrifugal type, resiliently mounted with direct drive or V-belt drive, adjustable variable pitch motor pulley high efficiency motor. Motor permanently lubricated with built-in thermal overload protection.

F. Evaporator Coil: Constructed of copper tubes expanded onto copper fins. Stainless steel drain pan with piping connection. Factory leak tested under water.

G. Compressor: Hermetically sealed, resiliently mounted with positive lubrication, and internal motor overload protection. Furnish internal vibration isolators, short cycle protection.

H. Refrigeration circuit: Furnish the following for each circuit thermal expansion valve, filter-drier, suction, discharge, and liquid line service valves with gauge ports, high and low pressure safety controls. Dehydrate and factory charge each circuit with oil and refrigerant.

I. Condenser:

1. Coil: Copper tube copper fin coil assembly and coil guard. Factory leak tested under water.
2. Condenser Fan: Direct drive propeller fans statically and dynamically balanced. Wired to operate with compressor. Motor permanently lubricated with built-in thermal overload protection. Furnish high efficiency fan motors.

J. Gas-Fired Heating Section:

1. Fuel: Natural gas if so scheduled.
2. Heat Exchangers: Stainless steel, welded construction.
3. Gas Burner: Induced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot. Require unit fan operation before allowing gas valve to open.

K. Air Filters: 2 inch thick glass fiber disposable media in metal frames. 25 to 30 percent efficiency based on ASHRAE 52.1.

L. Mixed Air Casing:

1. Economizer:
   a. Factory installed fully modulating motorized outside air and return air dampers controlled by dry bulb controller with minimum position setting.
   b. Outside air damper normally closed and return air damper normally open.
   c. Furnish barometric relief damper capable of closing by gravity.
   d. Furnish rain hood with screen.
   e. Provide economizer components and controls.

M. Controls:

1. Furnish control to provide low ambient cooling to 0 degrees F.
2. Furnish low limit thermostat in supply air to close outside air damper and stop supply fan.
3. Furnish terminal strip on unit for connection of operating controls to remote panel.
4. Thermostat: 365 days programmable electronic space thermostat with 1 stage heating and 2 stage cooling with manual changeover and heating setback and cooling setup capability.
5. Furnish interface to Building Automation System.
6. Microprocessor Based Controls:
   a. Factory mounted with the following features:
      1) Monitor each mode of operation.
      2) Evaporator fan status.

3) Filter status.
4) Indoor air quality.
5) Supply air temperature.
6) Outdoor air temperature.

b. Diagnostics for thermostat or temperature sensor commands for staged heating, staged cooling, fan operation, and economizer operation.

c. Zone space temperature sensor to interface with microprocessor controls with Automatic programmable with night setback.

N. Accessories:

1. Convenience Outlet: Factory installed, 115 volt, 15 amp, GFCI type, internally mounted.
2. Roof Curb Adaptor Package: Furnish duct support hardware to adapt unit to existing roof curb.
3. Factory installed ultraviolet C light located downstream of cooling coil.

2.2 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. Disconnect Switch: Factory mounted, non-fused type, interlocked with access door, accessible from outside unit, with power lockout capability.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof Curb:

1. Assemble roof curb.
2. Install roof curb level.
3. Coordinate curb installation and flashing with other trades.
4. Install units on roof curb providing watertight enclosure to protect ductwork and utility services.
5. Install gasket material between unit base and roof curb.

B. Connect units to supply and return ductwork with flexible connections.

C. Install components furnished loose for field mounting.

D. Install electrical devices furnished loose for field mounting.

E. Install control wiring between unit and field installed accessories.

3.2 INSTALLATION - NATURAL GAS HEATING SECTION

A. Connect natural gas piping to unit, full size of unit gas train inlet. Arrange piping with clearances for burner service.

B. Install the following piping accessories on natural gas piping connections.

1. Strainer.
2. Pressure gage.
3. Shutoff valve.
4. Pressure reducing valve.

C. Install natural gas piping accessories above roof and readily accessible.

3.3 MANUFACTURER'S FIELD SERVICES

A. Furnish initial start-up and shutdown during first year of operation, including routine servicing and checkout.

3.4 CLEANING

A. Vacuum clean coils and inside of unit cabinet.

B. Install new throwaway filters in units at Substantial Completion.

C. Install temporary filters during construction period. Replace with permanent filters at Substantial Completion.

3.5 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Train LAWA Maintenance personnel to adjust, operate and maintain the packaged rooftop air conditioning unit – non custom.

C. Provide a minimum of 12 hours (3 hours) of classroom and hands on training to LAWA Maintenance personnel.

END OF SECTION 23 81 03

SECTION 23 81 06 - PACKAGED ROOFTOP AIR CONDITIONING UNITS - CUSTOM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes equipment types that contain all the components of the refrigeration process within a single package.

1. Packaged rooftop air conditioning unit (larger than 5 tons).
2. Roof curb.

1.2 REFERENCES

A. AMCA Standard 99: Standards Handbook

B. AMCA /ANSI Standard 204: Balance Quality and Vibration Levels for Fans

C. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings

D. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans

E. AMCA Standard 500: Test Methods for Louvers, Dampers and Shutters

F. ARI Standards: 210/240, 270, 410, and 435

G. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter

H. Unit shall be designed to conform to ANSI/ASHRAE 15, latest revision.

I. Unit shall be certified in accordance with ANSI Z21.47 Standards.

J. ASHRAE/ANSI Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems

K. UL Standard 1995: Heating and Cooling Equipment

L. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

M. Equipment shall be UL or ETL listed.

N. Roof curb shall be designed to conform to NRCA Standards.

1.3 SUBMITTALS

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.

3. Weights.
4. Rough-in connections and connection requirements.
5. Duct connections.
6. Electrical requirements with electrical characteristics and connection requirements.
7. Controls.
8. Accessories.

B. Test Reports: Submit results of factory test at time of unit shipment.

C. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 TESTING

A. Equipment shall be factory run tested for a minimum of eight hours to ensure proper operation.

B. Factory test shall be witnessed by the Owner's representative (2 people) prior to shipping to the project site.

1.5 WARRANTY

A. Provide 5 years parts and labor warranty for compressors, VFD, motors and Ultraviolet Disinfection System, from the date of substantial completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Packaged Rooftop Cooling Unit. Provide outdoor rooftop mounted electrically controlled cooling unit utilizing multiple compressors as specified herein for cooling.

B. Manufacturers
   1. Mammoth
   2. Energy Labs
   3. Governair

2.2 EQUIPMENT

A. Cabinet and Frame
   1. The unit base frame shall be fabricated with 6-inch, 10.2 lb. per foot, structural steel C-channel.
   2. Structural cross members shall be placed at critical locations to support internal components.

3. Vertical frame members shall be fabricated from formed 11-gauge channels.
4. The unit base frame shall be furnished with lifting lugs capable of accepting cable or chain hooks for rigging.
5. Prior to unit assembly, the entire frame shall be covered with a minimum one-mil coat of air-dried sandstone rust inhibiting coating for maximum corrosion protection.
6. Internal floor liners shall be fabricated from 14-gauge galvanized steel welded to the base frame and sealed to prevent air leakage.
7. The entire unit length shall include an underliner constructed of 20-gauge galvanized steel to contain insulation and provide additional structural support.
8. The air handler cabinet casing shall utilize double wall sandwich construction.
9. The exterior surfaces of the wall shall form the air seal and shall be fabricated from 20-gauge galvanized steel.
10. The interior shall be lined with 20-gauge galvanized steel.
11. The exterior panels shall be galvanized steel, pre-coated with 6 mils of phenolic baked coating which will withstand 5,000 hours of salt spray per ASTM B-117 over 4 mils epoxy primer for a total of 10 mils for marine environments.
12. The unit base shall be insulated with 4-inch, 1-pound density of fiberglass insulation with a minimum R-value of 13.
13. Wall and roof panels shall be insulated with 2-inch, 1-pound density fiberglass with a minimum R-value of 6.9. Compressing 2" insulation between 1" panels is not acceptable.
14. A 4-inch space shall be provided between the air handler top liner and the roof panels to accommodate refrigerant piping and electrical runs.
15. Electrical wiring shall be run in a full-length electrical raceway above the air handler top liner.
16. Exterior roof panels shall be crowned for drainage and easily removable for service access.

B. Access Doors

1. A full-size hinged access door shall be provided for any section requiring service access. Removable casing panels shall not be allowed. Door frame shall be of rigid extruded aluminum. Adhesive-backed gasket applied to the frame shall not be allowed. Access doors shall be thermally broken and provided to the following components at a minimum: supply and return fan motors, supply and return fan inlets, filters, dampers, cooling/heating coils and any other serviceable component. Hinged access doors shall be complete with stainless steel hinges and multiple-point, single-handle compression-type latches to provide quick access and a positive air seal. Latch shall include integral keyed lock. Interior latch allows door closure during inclement weather. Doors shall include locking type door retainers to protect doors against wind damage when open. Doors shall be nominal 18- or 24-inch or 36-inch width. Actual opening widths shall be 17.25 inches and 29.25 inches respectively.
2. Door safety restraints provide a 2-turn secondary latch which shall prevent unwanted rapid door opening against high interior pressures.
3. Each fan section access door shall include a secondary door. This door shall be

constructed of expanded metal in a rigid frame which shall allow visual inspection of the fan, motor, and drive components. To gain access to the fan through this door requires the use of a tool.

4. Each door shall include a view port to allow visual inspection of interior components.

2.3 FANS

A. Type: Double inlet, centrifugal type fan.

B. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301, tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

D. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with copper tube and grease fitting rigidly attached to casing.

E. Mounting: Locate fan and motor internally on welded steel base coated with corrosion resistant paint. Factory mount motor on slide rails. Furnish access to motor, drive, and bearings through removable casing panels or hinged access doors. Mount base on spring vibration isolators.

F. Flexible Connection: Separate unit from connecting ductwork.

2.4 VARIABLE FREQUENCY DRIVES

A. VFDs for supply fans and return fans and condenser fans shall be mounted and wired by the unit manufacturer inside of ventilated NEMA 3R enclosures. See Section on VARIABLE FREQUENCY DRIVES.

2.5 REFRIGERANT COILS

A. Air-Cooled Condensing Section: Condenser coils shall be constructed of seamless copper tubes, mechanically expanded into copper fins. Each coil shall include an integral 10 degree F sub-cooling circuit. The mechanical refrigerant system shall be capable of operating at ambient conditions down to 0 degree F and shall include ASME receivers on all circuits and ASME relief valve on all circuits. Condenser fans shall be direct drive, propeller type. Fans shall be VFD controlled to vary the speed to maintain a minimum head pressure. Condenser deck shall be insulated.

B. Compressors: The compressor shall be scroll or screw type. Compressors shall be high efficiency, suction-gas cooled, single speed, hermetic type, with three Teflon bearings and a cast iron motor frame. Compressors shall be mounted on rubber-in-shear isolators. The compressor circuit shall include high and low pressure taps, a discharge service valve, and a check valve at the discharge outlet to prevent reverse rotation. Compressors shall have internal motor protection for over-temperature and over-current conditions. Other safety devices include a crankcase heater, high-pressure cutout, and low pressure freeze protection. Capacity reduction shall be performed with compressor staging and hot gas bypass on tandem compressor models. Capacity reduction shall be performed with hot gas bypass on non-tandem compressor models.

C. Mechanical Pressure-Controlled Hot Gas Bypass: A pressure-controlled modulating hot gas bypass valve will trim the #1 compressor's effective capacity. The valve shall be controlled between each and every compressor control stage. The valve follows the cooling demand and must be commanded fully closed before a compressor stage is enabled and commanded to its maximum open position (adjustable) before a stage is disabled.

D. Refrigeration Circuit Specialties: Each independent refrigerant circuit shall be completely piped, tested, dehydrated, and fully charged with oil and refrigerant R410A or R407C. Each refrigerant circuit includes compressor, condenser with integral liquid sub-cooler, liquid line service and charging valve, filter drier, sight glass, fusible plug, and thermostatic expansion valve.

E. Evaporator Coil: Direct expansion coil shall be constructed of seamless coated copper tubes expanded into copper fins and shall not be less than three rows in depth, nor have more than 12 fins per inch. Coil casing shall be constructed of type 201 stainless steel. Headers shall be copper. Evaporator coil shall be provided with adjustable superheat controls and external equalizers. Coils shall be tested to be leak-free with nitrogen at 500 PSIG under water. The entire refrigerant piping circuit shall be leak tested at 150 PSIG air pressure.

F. The evaporator coil shall be provided with a drain pan which shall be fabricated of 14-gauge 201 stainless steel and sloped for positive drainage of condensate. A 1-1/4-inch diameter condensate drain connection shall be provided on one side of the unit for slab coils and on both sides of the unit for V-bank coils and shall be field trapped by others.

G. All coils (evaporator and condenser) shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339. Finned-tube coils applied coating shall have 5 year warranty.

2.6 DAMPERS, HOODS, AND LOUVERS

A. Low Leak Outside Air/Return Air (OA/RA) Dampers: Outside air and return air (economizer) dampers shall be constructed of heavy gauge, aluminum airfoil-shaped blades and 14-gauge galvanized steel frames. The damper blades shall be mounted to plated square shafts which rotate in permanently-lubricated nylon bearings to insure smooth operation. Vinyl blade seals shall be locked into extruded aluminum blade slots. Side seals shall be constructed of flexible metal compression-type stainless steel. Damper blades operate without clatter or binding and damper linkage will be located out of the air stream. Actuator shall be direct-mounting type.

B. Outside Air Louvers - Economizer: Outside air louvers shall be of a storm-proof design and provided with a 2-inch by 2-inch galvanized bird screen. A fully-insulated divider deck shall be provided to separate outside air from return air.

2.7 FILTRATION SYSTEMS

A. Various filter types are specified in HVAC AIR CLEANING DEVICES, Section 23 40 00.

B. Ultra Violet Germicidal Irradiation (UVGI) system, Section 23 42 00.

C. Photocatalytic Oxidation (PCO) system, Section 23 41 00.

2.8 ELECTRICAL

A. General: All electrical wiring conforms to UL 1995. Where required, wiring will be run in EMT. The unit shall be equipped for single source power connection.

B. Main Control Panel - Exterior: The main control panel will have access door(s) for direct access to the controls. The panel shall be equivalent to NEMA type 3R (rainproof) and contain a single externally-operated, molded case switch (non-automatic circuit breaker) suitable for copper wire up to and including 3-inch conduit. Low-voltage control panel wiring shall be enclosed in a wiring duct.

C. Service Outlet and Lights: GFI-type service outlet(s) shall be provided. Power is provided from the main unit. Circuit shall remain energized regardless of main unit disconnect position.

D. Lights not in the air stream shall be fluorescent with a wire guard. Lights in the air stream shall be vapor-proof screw-in type fluorescent with a cast alloy base with threaded hubs, gasketed glass cover, and wire guard. Lights are wired to a single switch. Power shall be on the same circuit as the Service Outlet. Light circuit shall remain energized regardless of main unit disconnect position.

2.9 CONTROLS

A. A microprocessor controller shall be installed in the proximity to the air conditioning unit. The air conditioning unit will be provided with all necessary temperature, pressure sensors, filter switches and wiring for complete temperature controls and economizer operation as indicated on the control drawings.

B. Unit controller shall have capability as standard for remote access and monitoring over the internet.

C. Building BAS Interface. Provide an interface between the unit controls and the BMS and the FMCS.

2.10 ROOF CURB

A. Factory assembled galvanized steel mounting curb designed and manufactured by unit manufacturer.

1. All roof top equipment including packaged rooftop air conditioning units are to be curb mounted.
2. Perimeter type with support of air handling sections.
3. Furnish supply and return opening duct frames as part of curb structure allowing duct connections to be made directly to curb.
4. Minimum of 12 inches high.
5. Furnish gaskets for field mounting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Furnish services of factory trained representative for minimum of one day to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, calibrate controls, and instruct LAWA on operation and maintenance.

C. Training to include minimum of eight LAWA personnel for 40 hours training, 16 hours shall be classroom training per person and 24 hours shall be hands-on field training per person.

D. Training shall occur after the system is fully operational.

END OF SECTION 23 81 06

SECTION 23 81 07 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes all variable frequency drives. All standard and optional features shall be included within the VFD panel

1.2 QUALITY REQUIREMENTS

A. Manufacturer testing

1. To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.
2. All optional features shall be functionally tested at the factory for proper operation.

1.3 SUBMITTALS

A. Shop Drawings and Product Data.

B. Variable Frequency Drives

1. Submit complete wiring diagrams, dimensional drawings, transformer data and connection diagrams.
2. Outline dimensions, conduit entry locations and weight.
3. Complete technical product description include a complete list of options provided
4. Customer connection and power wiring diagrams.
5. Compliance to IEEE 519 B harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
    a. The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFDs shall include a minimum of 5% impedance reactors, no exceptions.

1.4 WARRANTY

A. Warranty shall be 5 years from the date of certified start-up. The warranty shall include all parts, labor, travel time and expenses. There shall be support available via a toll free phone number.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Variable Frequency Drives:

1. Description:

   a. Motors shall be provided with UL Listed variable frequency drive (VFD) control systems.

   b. The VFD shall be UL Type 1 or UL Type 12 for indoor applications or UL NEMA-3R for outdoor applications as required on the schedule. The VFD shall have been evaluated by UL and found acceptable for mounting in a plenum or other air handling compartment. Manufacturer shall supply a copy of the UL plenum evaluation upon request.

   c. The VFD shall be tested to UL 508C. The appropriate UL label shall be applied. VFD shall be manufactured in ISO 9001, 2000 certified facilities.

   d. The VFD and any optional panels, of any type (bypass, etc.) shall be UL listed for a short circuit current rating of 100,000 amps and labeled with this rating.

2. Manufacturers.

   a. **Danfoss.**

   b. **Yaskawa.**

   c. **ABB.**

3. General

   a. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating. When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

   b. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.

   c. The VFD shall have a dual 5% impedance DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical. The VFD full load output current rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting. VFDs through 200 HP shall have internal swinging (non-linear) chokes providing impedance equivalent

to 5% to reduce the harmonics to the power line. Swinging choke shall be required resulting in superior partial load harmonic reduction. Linear chokes are not acceptable. 5% impedance may be from dual (positive and negative DC bus) chokes, or 5% swinging AC line chokes.

d. The VFD full load output current rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.

e. The VFD shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed derating or low speed excessive magnetization, as would occur if a constant torque V/Hz curve was used at reduced speeds. Breakaway torque of 160% shall be available.

f. A programmable automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.

g. The VFD must be able to produce full torque at low speed to operate direct drive fans.

h. Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.

i. An automatic motor adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test.

j. Galvanic isolation shall be provided between the VFDs power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.

k. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.

l. All VFDs shall contain integral EMI filters to attenuate radio frequency interference conducted to the AC power line.

4. Protective Features

a. A minimum of Class 20 I2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

b. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.

c. Protect VFD from input phase loss. The VFD should be able to protect itself

from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.

d. Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.

e. Protect from over voltage. The VFD shall continue to operate without faulting with an input voltage as high as 130% of the nominal voltage.

f. The VFD shall incorporate a programmable motor preheat feature to keep the motor warm and prevent condensation build up in the motor when it is stopped in a damp environment by providing the motor stator with a controlled level of current.

g. VFD shall include a "signal loss detection" algorithm with adjustable time delay to sense the loss of an analog input signal. It shall also include a programmable time delay to eliminate nuisance signal loss indications. The functions after detection shall be programmable.

h. VFD shall function normally when the keypad is removed while the VFD is running. No warnings or alarms shall be issued as a result of removing the keypad.

i. VFD shall catch a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.

j. Selectable over-voltage control shall be provided to protect the drive from power regenerated by the motor while maintaining control of the driven load.

k. VFD shall include current sensors on all three output phases (or two output phases and DC Bus current) to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify that one of the output phases is low or lost.

l. If the temperature of the VFD's heat sink rises to 80 degree C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.

m. The VFD shall have cooling fan(s) for better energy efficiency, minimizing losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.

n. The VFD shall store in memory the last 3 faults. A description of the fault, and the date and time of the alarm shall be recorded. The VFD shall include graphing capability for the last 2 alarms to provide additional diagnostic analysis.

o. When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.

5. Interface Features

   a. Hand, Off and Auto keys shall be provided to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.

   b. There shall be an "Info" key on the keypad. The Info key shall include "on-line" context sensitive assistance for programming and troubleshootingThe VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.

   c. Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.

   d. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.

   e. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status.

   f. Display shall be programmable to communicate in multiple languages including English and Spanish.

   g. A red FAULT light, a yellow WARNING light(or flashing green WARNING light) and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

   h. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.

   i. A minimum of two feedback PID controller to control the speed of the VFD shall be standard.

      (1) This controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common setpoint or to individual setpoints and to automatically select either the maximum or the feedback signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.

      (2) The VFD shall be able to apply individual scaling to each feedback signal.

      (3) For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.

      (4) The VFD's PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the

controlled system.

j. The VFD shall have at least two additional PID controller which can be used to control damper and valve positioners in the system and to provide setpoint reset.

k. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

l. A minimum of four simultaneous meter displays shall be available. They shall include at a minimum, frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, among others.

m. Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set "sleep" level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PID controller, it shall be possible to program a "wake-up" feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.

n. A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.

o. VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-w.g.), pressure per square inch (psi) or temperature (°F).

p. VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

q. Standard Control and Monitoring Inputs and Outputs

(1) Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

(2) Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.

(3) Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.

i. Each shall be independently selectable to be used with either an analog voltage or current signal.

ii. The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.

iii. A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.

iv. The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting,

(5) One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.

(6) It shall be possible through serial bus communications to read the status of all analog and digital inputs of the VFD.

(7) It shall be possible to command all digital and analog output through the serial communication bus.

s. Optional Control and Monitoring Inputs and Outputs

(1) It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.

(2) These modules shall use rigid connectors to plug into the VFD's control card.

(3) The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.

(4) Modules may include such items as:

i. Additional digital outputs, including relay outputs

ii. Additional digital inputs

iii. Additional analog outputs

iv. Additional analog inputs, including Ni or Pt temperature sensor inputs

(5) It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

t. Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in firefighter's override mode. Firemode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.

u. A real-time clock shall be an integral part of the VFD.

(1) It shall be possible to use this to display the current date and time on the VFD's display.

(2) Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter setpoints and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and

others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.

(3) All VFD faults shall be time stamped to aid troubleshooting.

(4) It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.

(5) The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.

v. The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

w. The VFD shall include a Smart logic controller to provide advanced control interface capabilities. The Smart logic controller also will allow to operate in closed loop set point (PID) control mode with one motor at a controlled speed and control the operation of 2 additional constant speed motor starters (Cascade Control).

(1) Comparators for comparing VFD analog values to programmed trigger values

(2) Logic operators to combine up to three logic expressions using Boolean algebra

(3) Delay timers

(4) A 20-step programmable structure

(5) The Smart Logic controller will allow the VFD to operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 2 additional constant speed motor starters. (Cascade Control).

6. Serial Communications

a. The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:

(1) Johnson Controls Metasys N2

(2) Modbus RTU

(3) BACnet MS/TP

b. VFD shall have 232 port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.

c. The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

7. Adjustments

a. The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

b. Four independent setups shall be provided.

c. Multiple preset speeds per setup shall be provided for a minimum total of 8.

d. Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 1,800 seconds.

e. Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period.

f. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, , and VFD overload.

g. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

h. An automatic "start delay" may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.

i. Minimum of three programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Automated setting of lockout ranges shall simplify the set-up.

8. Optional Features

a. All optional features shall be built and mounted by VFD manufacturer. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

b. All panels shall be marked for 100,000 AMP short circuit current rating in compliance with UL.

c. The enclosure rating of the VFD w/options shall be consistent with the VFD rating of either NEMA/UL type 1 or NEMA/UL type 12, as required for the installation location and/or as called for on the schedule. The package shall include ALL optional devices and shipped as a complete factory tested assembly.

d. Three-Contactor bypass shall be provided that allows operation of the motor via line power in the event of a failure of the VFD. Motor control selection shall be through either a VFD output contactor or a bypass contactor that are electrically interlocked to ensure that both contactors are not energized simultaneously. A third contactor, the drive input contactor, shall be supplied as standard. This allows the powering of the VFD with the motor off or operating in bypass mode for testing, programming and troubleshooting purposes. As an option, the tree-conductor bypass may be allowed.

e. The three-contactor bypass shall include the following interface and control features:

(1) Mode selection via a three position DRIVE/OFF/BYPASS/ switch.

i. DRIVE Mode: Both the drive input and output contactors are closed and the motor is operated via VFD power

ii. OFF Mode: DRIVE input, drive output and bypass contactors are all open.

iii. BYPASS Mode: Bypass contactor is closed and motor is operating from line power. Both the drive input and drive output contactors are open for servicing of the VFD without power.

iv. TEST Mode: Bypass contactor is closed and the motor is operated from line power. The drive input contactor is closed but the drive output contactor is open. This allows for the testing and programming of the VFD while the motor is operated via line power.

(2) Contactors shall operate from a 24vdc. three phase power supply that shall function off of any two legs of the AC line and shall maintain power on the loss of any one of the AC lines.

(3) A bypass pilot light is supplied to indicate that the motor is operating from line power.

(4) Common start/stop command when operating in either bypass or VFD mode.

(5) Selectable Run Permissive logic shall operate in either VFD or bypass operation. When activated, any command to start the motor, in either hand bypass, remote bypass, hand VFD or remote VFD shall not start the motor, but instead close a relay contact that is used to initiate operation of another device, such as an outside air damper. A contact closure from this device shall confirm that it is appropriately actuated and the motor shall then start.

(6) Bypass package shall include an external safety interlock that will disable motor operation in either bypass or VFD when open.

(7) Firemode bypass operation shall be standard. When activated via a contact closure, the motor shall transfer to bypass (line power) regardless of the mode selected. All calls to stop the motor shall be ignored. These include the opening of the start command, an external safety trip or the tripping of the motor overload. Firemode operation will take precedence over all other commands.

(8) The bypass must include a selectable time delay of 0 to 60 seconds before the initiation of bypass operation. When transferring from VFD to bypass modes, the time delay starts after the motor has decelerated to zero speed. This delay allows the BAS to prepare for bypass operation. Bypass packages that do not include a time delay, or do not include a selectable delay period, will not be acceptable.

(9) Automatic bypass shall be selectable. When active, the motor shall be transferred to line power on a VFD fault condition. The bypass time delay shall be activated prior to this transfer to line power to allow the VFD time

to attempt to recover from the fault condition prior to running in bypass.

f. Protective Features

(1) Main input disconnect shall be provided that removes power from both the bypass and VFD.

(2) Main input motor rated fuses that protect the entire package.

(3) VFD only fast acting input fuses shall be provided. Packages that include only main input motor rated fusing or circuit breaker are not acceptable.

(4) Overload protection shall be supplied in bypass mode.

i. This overload shall supply minimum class 20 protection as well as wide adjustable current setting for complete motor protection when operating on line power. Those overloads that are not class 20 or current selectable will not be acceptable.

ii. Overload protection shall include phase loss and phase imbalance protection.

(5) Low voltage contactor operation shall be maintained to 70% of the packages nominally rated voltage. This will ensure VFD operation on low voltage conditions that would otherwise be interrupted due to contactor dropout.

(6) The VFD shall be able to operate the motor at a reduced load with the loss of any one of the three phases of power. Contactors shall remain closed regardless of which phase is lost. This will ensure VFD operation on single phase conditions that would otherwise be interrupted due to contactor dropout.

g. Line/Load Conditioners

(1) VFDs that do not include 5% DC link impedance shall include 5% AC line reactors in the operations enclosure. Lower levels of impedance will not be acceptable.

(2) When the installation requires additional motor dV/dT protection, it shall be via a dV/dT filter mounted in the options enclosure. Packages that include only load reactors or filters supplied separately will not be accepted.

9. Service Conditions

a. Ambient temperature, continuous, full speed, full load operation:

(1) -10 to 45°C (14 to 113°F) through 125 HP @ 460 and 600 volt, through 60 HP @ 208 volt

b. 0 to 95% relative humidity, non-condensing.

c. Elevation to 3,300 feet without derating.

d. AC line voltage variation, -10 to +10% of nominal with full output.

e. No side clearance shall be required for cooling.

f. All power and control wiring shall be done from the bottom.

g. All VFDs shall be plenum rated.

10. Quality Assurance

a. To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

b. All optional features shall be functionally tested at the factory for proper operation.

PART 3 - EXECUTION

3.1 START-UP SERVICE

A. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

B. Harmonic filtering. The VFD supplier shall, with the aid of the buyer's detailed electrical power single line diagram showing all impedances in the power path to the VFDs, perform an analysis to initially demonstrate the supplied equipment will met the IEEE recommendations after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the drive supplier quotation.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Train LAWA Maintenance personnel after the system is fully operational.

C. Provide minimum of 12 hours (3 shifts) of classroom and hands on training to LAWA Maintenance personnel.

END OF SECTION 23 81 07

SECTION 23 81 23 - COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes air conditioning units, controls and control panels.

1.2 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute

1. ARI 210/240 - Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.
2. ARI 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning & Air-Source Heat Pump Equipment.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

C. American Society of Mechanical Engineers:

1. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.

D. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s literature and data indicating water, drain, refrigeration, and electrical characteristics and connection requirements.

B. Manufacturer's Installation Instructions: Submit procedures for rigging and making service connections.

C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

D. Manufacturer's Field Reports: Indicate conditions at initial start-up including date, and initial set points.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years

1.5 WARRANTY

A. Furnish five-year manufacturer's warranty.

1.6 MAINTENANCE SERVICE

A. Furnish service and maintenance of units for one year from Date of Substantial Completion.

B. Examine unit components monthly. Clean, adjust, and lubricate equipment.

C. Include systematic examination, adjustment, and lubrication of unit, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

D. Perform work without removing units from service during building normal occupied hours.

E. Provide emergency call back service at all hours for this maintenance period.

F. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service without unreasonable loss of time.

G. Perform maintenance work using competent and qualified personnel under supervision of manufacturer or original installer.

H. Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of LAWA.

1.7 EXTRA MATERIALS

A. Furnish one set of spare filters for each unit.

PART 2 - PRODUCTS

2.1 FLOOR MOUNTED AIR CONDITIONING UNITS

A. Manufacturers:

See the IT Design Guidelines section of the LAWA Guide Specifications.

B. Product Description: Packaged, water or air cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fans filters, humidifier and controls, reheat and heating coils. Refrigerant shall be R407C or R410A.

C. Cabinet and Frame:

1. Structural Frame: 14 gauge welded steel suitably braced for rigidity, capable of supporting compressors and other mechanical equipment and fittings with welded tubular steel floor stand with adjustable legs and vibration isolation pads.

2. Doors and Access Panels: 20 gauge galvanized steel with polyurethane gaskets, hinges to allow removal of panels, and concealed fastening devices.
3. Insulation: Thermally and acoustically line cabinet interior with 1 inch thick acoustic duct liner.
4. Finish of Exterior Surfaces: Shop coated with 4.0 mils epoxy primer and 6.0 mils topcoat phenolic baked coating for a total of 10.0 mils. Coating shall withstand 5,000 hour of salt spray test in accordance with ASTM B117.

D. Evaporator Fans and Motors:

1. Fans: Double inlet, forward curved centrifugal fans, statically and dynamically balanced.
2. Motor: Drip proof, permanently lubricated ball bearing motor with built-in current and overload protection.
3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, keyed, variable and adjustable pitch motor sheave, minimum of two matched belts, drive rated minimum 2.0 times nameplate rating of motor.

E. Compressors:

1. Type: Hermetic with resilient suspension system, oil strainer, crankcase sight glass, internal motor protection, low pressure switch, manual reset high pressure switch.
2. Compressors: Individually serviceable without dismantling other components or removing unit from service.
3. Refrigeration Circuits: Two, each with hot gas mufflers, thermal expansion valve with external equalizer, liquid line solenoid valve, liquid line filter-drier, refrigerant sight glass with moisture indicator, service shut-off valves and charging valves and accumulator sized for liquid seal under light load.

F. Evaporator Coils:

1. Direct expansion cooling coils of seamless copper tubes expanded into copper fins.
2. Mount coil assembly in stainless steel drain pan.

G. Condensers:

1. Water Cooled: Shell and tube type ASME Section VIII or Coaxial tube in tube type with liquid line stop valve and head pressure actuated water regulating valve. Terminate outside cabinet for easy external connections.
2. Air Cooled: Corrosion resistant cabinet, copper tube copper fin coils arranged for two circuits, multiple direct drive propeller fans with permanently lubricated ball bearing single phase motors with internal overload protection. Furnish capacity control by cycling fans.

H. Water Coil:

1. Seamless copper tubes expanded into copper fins with control valve and strainer.

I. Filters:

1. Media: Pleated, lofted, non-woven, reinforced cotton fabric; supported and bonded to welded wire grid; enclosed in cardboard frame; 2 inch nominal thickness.
2. Rating, ASHRAE 52.1:
    a. Dust spot efficiency: 25-30 percent.
    b. Weight resistance: 90-92 percent.
    c. Initial resistance at 500 fpm face velocity: 0.30 inch WG.
    d. Recommended final resistance: 1.0 inch WG.

J. Refrigerant Reheat Coil:

1. Hot gas refrigerant coil of seamless copper tubes expanded into copper fins with three-way solenoid valve on first stage refrigerant circuit.

K. Reheat/heating Coils:

1. Heating Coils: Enclosed fin electrical elements arranged for minimum of two stages.
2. Circuit Protection: Primary and secondary thermal cutouts, differential air pressure switch, and manual reset overload protection and branch circuit overcurrent protection.
3. Hot water heating coil of seamless copper tubes expanded into copper fins.

L. Humidifier:

1. Infrared Type: High intensity quartz lamps mounted above stainless steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; pre-piped and utilizing condensate water from cooling coils with stainless steel or brass float valve mechanism; located in bypass air stream.

M. Control Cabinet: NEMA 250; Type 2 enclosure, UL listed, with piano hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control circuit transformer.

N. Disconnect Switch: Non-automatic molded case circuit breaker with handle accessible with panel closed and capable of preventing access until switched to "off" position.

O. Electronic Control System:

1. Solid state with start button, stop button, temporary loss of power indicator, manual reset circuit breakers, temperature control humidity control, and monitor panel.
2. Monitor Panel: Back lighted with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of air flow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
3. Temperature and Humidity Control Modules: Solid state plug-in with adjustable set point, "push-to-test" calibration check button, and built-in visual indicators to indicate mode of operation.
4. Location: Through hinged door in front of unit; isolated from conditioned air stream to allow service while system is operating.

P. Outdoor Unit Casing Coating

1. Zinc chromate, iron oxide, shop coated with 4.0 mils epoxy primer and 6.0 mils topcoat phenolic baked coating for a total of 10.0 mils. Coating shall withstand 5,000 hour of salt spray test in accordance with ASTM B117.
2. Finish exceeds 5000 hour salt spray test in accordance with ASTM B117.

Q. Outdoor Unit Coil Coating.

1. All coils shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339. Finned-tube coils applied coating shall have 5 year warranty.

R. Leak Detection.

1. Provide underfloor leak detection system for the raised floor installations.

2.2 AIR CONDITIONING UNITS

A. Manufacturers:

See the IT Design Guidelines section of the LAWA Guide Specifications.

B. Product Description: Self-contained air cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fan, filters, humidifier, controls.

C. Assembly: For horizontal ceiling mounting to fit 24 x 48 inches T-bar ceiling opening.

D. Cabinet: 14 gauge welded steel with baked enamel finish, and lined with 1/2 inch thick acoustic duct liner.

E. Provide condensate pump integrated with unit.

F. Evaporator Fan: Forward curved centrifugal, directly driven by two-speed motor.

G. Compressor: Hermetic with resilient suspension system, oil strainer, internal motor overload protection, low pressure switch, manual reset high-pressure switch.

H. Evaporator Coil: Direct expansion cooling coil of seamless copper tubes expanded into aluminum fins, with thermal expansion valve with external equalizer, liquid line filter-drier, service shut-off valves and charging valves. Mount coil assembly in stainless steel drain pan.

I. Air Cooled Condenser: Integral copper tube copper fin coil sized for scheduled capacity.

J. Outdoor Unit Coil Casing Coating

1. Zinc chromate, iron oxide, shop coated with 4 mils epoxy primer and 6 mils topcoat phenolic baked coating for a total of 10 mils. Coating shall withstand 5,000 hour of salt spray test in accordance with ASTM B117.
2. Finish exceeds 5000 hour salt spray test in accordance with ASTM B117.

K. Outside Coil Coating

1. All coils shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339. Finned-tube coils applied coating shall have 5 year warranty.

L. Filter: 1 inch thick disposable glass fiber media.

M. Heating Coils: Nichrome wire electric elements with contactor, dehumidification relay, and high temperature limit switch.

N. Evaporative Pan Type: Stainless steel pan and cover, with stainless steel or brass float valve mechanism, electric heating coil with low water cut-off switch, flush cycle timer and solenoid drain valve.

O. Control System:

1. Unit Mounted: Main fan contactor, compressor and condenser fan contactor, compressor start capacitor, controls transformer with circuit breaker, solid state temperature and humidity control modules.

2. Solid state wall mounted with start/stop switch, adjustable humidity setpoint, adjustable temperature setpoint to interface with unit mounted controls.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate installation of computer room air conditioning units with computer room raised floor. Floor mounted units shall be on level stand with 2" deflection spring isolators and seismic restraints. Units hung from above shall have 2" spring isolation hangers and seismic restraints.

B. Coordinate installation of air conditioning unit with computer room ceiling.

C. Install drainage piping connections for humidifier flushing system.

D. Install hot water heating piping connections to reheat coils. Install shut-off valves in hot water heating inlet and outlet piping.

E. Install refrigerant piping connections to air-cooled condensing units.

F. Install accessories furnished loose for field mounting.

G. Install electrical devices furnished loose for field mounting.

H. Install control wiring between control panel and field mounted control devices.

I. Provide connection to electrical service.

3.2 MANUFACTURER'S FIELD SERVICES

A. Furnish services of factory trained representative for minimum of one days to start-up, calibrate controls, and instruct a minimum of 8 LAWA personnel for 16 hours, 8 hours shall be classroom training and 8 hours shall be hands on training on operation and maintenance.

B. Set initial temperature and humidity set points.

3.3 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Train LAWA Maintenance personnel on the system operations and verify specified performance

C. Provide minimum of 16 hours each (3 shifts), 8 hours of classroom and 8 hours of hands on training to LAWA Maintenance personnel.

END OF SECTION 23 81 23

SECTION 23 81 26 - SPLIT-SYSTEM AIR-CONDITIONERS (DUCTED)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air Handling Unit.
2. Condensing unit.

B. This applies to the units with cooling capacity of 5 ton and below.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
4. ARI 365 - Commercial and Industrial Unitary Air-Conditioning Condensing Units.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
2. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ASTM International:

1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

D. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.

E. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.
3. Weights.
4. Rough-in connections and connection requirements.

5. Duct connections.
6. Electrical requirements with electrical characteristics and connection requirements.
7. Controls.
8. Accessories.

B. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.4 QUALITY ASSURANCE

A. Performance Requirements: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90.1 when used in combination with compressors and evaporator coils when tested in accordance with ARI Standards.

1.5 WARRANTY

A. Minimum one-year warranty on entire system and five (5) years for compressors.

PART 2 - PRODUCTS

2.1 SPLIT SYSTEM AIR CONDITIONING UNITS

A. Manufacturers:

1. Carrier.

2. Trane.

3. York.

B. Product Description: Split system consisting of air handling unit and condensing unit including cabinet, evaporator fan, refrigerant cooling coil, compressor, refrigeration circuit, condenser, air filters, controls, air handling unit accessories, condensing unit accessories, and refrigeration specialties.

C. Refrigerants R-410A and R-407C.

2.2 AIR HANDLING UNIT

A. Cabinet:

1. Panels: Constructed of galvanized steel with baked enamel finish. Access Panels: Located on both sides of unit. Furnish with duct collars on inlets and outlets.
2. Insulation: Factory applied to each surface to insulate entire cabinet. One inch thick neoprene coated aluminum foil faced glass fiber with edges protected from erosion.

B. Evaporator Fan: Forward curved centrifugal type, resiliently mounted with adjustable belt drive and high efficiency motor. Motor permanently lubricated with built-in thermal overload protection.

C. Evaporator Coil: Constructed of copper tubes expanded onto aluminum fins. Factory leak tested under water. Removable, PVC construction, double-sloped drain pan with piping connections on both sides.

D. Refrigeration System: Single or Dual refrigeration circuits controlled by factory installed thermal expansion valve.

E. Hot Water Heating Coil: Factory mounted Field installed with casing to match unit construction. Coil: Constructed of copper tubes expanded into aluminum fins. Factory leak tested under water.

F. Air Filters: 1 inch thick glass fiber disposable media in metal frames, 25 to 30 percent efficiency based on ASHRAE 52.1.

2.3 CONDENSING UNIT

A. General: Factory assembled and tested air cooled condensing units, consisting of casing, compressors, condensers, coils, condenser fans and motors, and unit controls.

B. Unit Casings: Exposed casing surfaces constructed of galvanized steel factory coated with 6.0 mils of phenolic backed coating that will withstand 5,000 hours of salt spray per ASTM B-117 over 4.0 mils epoxy primer for total of 10.0 mils. Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to compressors, controls, condenser fans, motors, and drives.

C. Compressor: Single refrigeration circuit or two independent refrigeration circuits with rotary or hermetic semi-hermetic reciprocating type compressors, resiliently mounted, with positive lubrication, and internal motor overload protection.

D. Condenser Coil: Constructed of copper tubing mechanically bonded to copper fins, factory leak and pressure tested. Coil shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339.

E. Controls: Furnish operating and safety controls including high and low pressure cutouts. Control transformer. Furnish magnetic contactors for compressor and condenser fan motors.

F. Condenser Fans and Drives: Direct drive propeller fans statically and dynamically balanced. Wired to operate with compressor. Permanently lubricated ball bearing type motors with built-in thermal overload protection. Furnish high efficiency fan motors.

G. Condensing Unit Accessories: Furnish the following accessories:

1. Controls to provide low ambient cooling to 0 degrees F.
2. Time delay relay.
3. Anti-short cycle timer.
4. Disconnect switch.
5. Vibration isolators.
6. Hot gas bypass kit.

7. Coil with corrosion resistant coating capable of withstanding salt spray test of 1000 hours in accordance with ASTM B117.
8. Condenser Coil Guard: Condenser fan openings furnished with PVC coated steel wire safety guards.
9. Suction and discharge pressure gauges.

H. Refrigeration specialties: Furnish the following for each circuit:

1. Charge of compressor oil.
2. Holding charge of refrigerant.
3. Replaceable core type filter drier.
4. Liquid line sight glass and moisture indicator.
5. Shut-off valves on suction and liquid piping.
6. Liquid line solenoid valve.
7. Charging valve.
8. Oil level sight glass.
9. Crankcase heater.
10. Hot gas muffler.
11. Pressure relief device.

2.4 CONTROLS

A. Capability to interface with BAS (Building Automation System).

PART 3 - EXECUTION

3.1 INSTALLATION - AIR HANDLING UNIT

A. Install per manufacturer's recommendations.

B. Install condensate piping with trap and route from drain pan to approved receptor.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Training LAWA Maintenance personnel to adjust, operate, and maintain the split system air conditioner.

C. Provide minimum of 8 hours each shift (3 shifts) of classroom and hands on training to LAWA Maintenance personnel.

END OF SECTION 23 81 26

SECTION 23 81 27 - DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fan Coil Unit.
2. Condensing unit.
3. For units/systems up to three tons maximum.

B. This applies to units less than 5 tons.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
4. ARI 365 - Commercial and Industrial Unitary Air-Conditioning Condensing Units.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
2. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ASTM International:

1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

D. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.

E. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.

3. Weights.
4. Rough-in connections and connection requirements.
5. Electrical requirements with electrical characteristics and connection requirements.
6. Controls.
7. Accessories.

B. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.4 QUALITY ASSURANCE

A. Performance Requirements: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90.1 when used in combination with compressors and evaporator coils when tested in accordance with ARI Standards.

PART 2 - PRODUCTS

2.1 SPLIT SYSTEM AIR CONDITIONING UNITS

A. Product Description: Split system consisting of fan coil unit and condensing unit including cabinet, evaporator fan, refrigerant cooling coil, compressor, refrigeration circuit, condenser, air filters, controls, air handling unit accessories, condensing unit accessories, and refrigeration specialties.

B. Manufacturers:

1. **Mitsubishi.**
2. **Daikin.**
3. **Sanyo.**

C. Refrigerants R-410A and R-407C.

2.2 FAN COIL UNIT

A. Cabinet:

1. Panels: Constructed of galvanized steel with baked enamel finish. Access Panels: Located on both sides of unit. Furnish with duct collars on inlets and outlets.
2. Insulation: Factory applied to each surface to insulate entire cabinet. One inch thick neoprene coated aluminum foil faced glass fiber with edges protected from erosion.

B. Evaporator Fan: Forward curved centrifugal type, resiliently mounted with adjustable belt drive and high efficiency motor. Motor permanently lubricated with built-in thermal overload protection.

C. Evaporator Coil: Constructed of copper tubes expanded onto copper fins. Factory leak tested under water. Removable, PVC construction, double-sloped stainless steel drain pan with

piping connections on both sides. Coil shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339.

D. Refrigeration System: Single or Dual refrigeration circuits controlled by factory installed thermal expansion valve. Refrigerant shall be R407C or R410A.

E. Air Filters: 1 inch thick glass fiber disposable media in metal frames. 25 to 30 percent efficiency based on ASHRAE 52.1.

F. Unit shall be wall mounted, ceiling mounted, or ceiling cassette type (integral with grid).

2.3 CONDENSING UNIT

A. General: Factory assembled and tested air cooled condensing units, consisting of casing, compressors, condensers, coils, condenser fans and motors, and unit controls.

B. Unit Casings: Exposed casing surfaces constructed of galvanized steel with manufacturer's standard baked enamel finish. Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to compressors, controls, condenser fans, motors, and drives.

C. Compressor: Single refrigeration circuit or two independent refrigeration circuits with rotary or hermetic semi-hermetic reciprocating type compressors, resiliently mounted, with positive lubrication, and internal motor overload protection. Compressor shall five (5) year warranty.

D. Condenser Coil: Constructed of copper tubing mechanically bonded to copper fins, factory leak and pressure tested. Coil shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339.

E. Controls: Furnish operating and safety controls including high and low pressure cutouts. Control transformer. Furnish magnetic contactors for compressor and condenser fan motors.

F. Condenser Fans and Drives: Direct drive propeller fans statically and dynamically balanced. Wired to operate with compressor. Permanently lubricated ball bearing type motors with built-in thermal overload protection. Furnish high efficiency fan motors.

G. Condensing Unit Accessories: Furnish the following accessories:

1. Controls to provide low ambient cooling to 0 degrees F.
2. Time delay relay.
3. Anti-short cycle timer.
4. Disconnect switch.
5. Vibration isolators.
6. Hot gas bypass kit.

7. Coil with corrosion resistant coating capable of withstanding salt spray test of 1000 hours in accordance with ASTM B117.
8. Condenser Coil Guard: Condenser fan openings furnished with PVC coated steel wire safety guards.
9. Suction and discharge pressure gauges.

H. Refrigeration specialties: Furnish the following for each circuit:

1. Charge of compressor oil.
2. Holding charge of refrigerant.
3. Replaceable core type filter drier.
4. Liquid line sight glass and moisture indicator.
5. Shut-off valves on suction and liquid piping.
6. Liquid line solenoid valve.
7. Charging valve.
8. Oil level sight glass.
9. Crankcase heater.
10. Hot gas muffler.
11. Pressure relief device.

2.4 CONTROLS

A. Capability to interface with BAS (Building Automation System).

PART 3 - EXECUTION

3.1 INSTALLATION – FAN COIL UNIT

A. Install per manufacturer's recommendations. Where appropriate, provide 2" deflection spring vibration isolators and seismic restraints.

B. Install condensate piping with trap and route from drain pan to approved receptor.

3.2 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 "Demonstration and Training" for demonstration and training requirements.

B. Training shall include minimum of 10 LAWA personnel for 40 hours three shifts total, 16 hours shall be classroom training and 24 hours shall be hands on training.

END OF SECTION 23 81 27

SECTION 23 82 19 – FAN COIL UNITS

PART 1- GENERAL

1.1 SUMMARY

A. This Section includes fan coil units and accessories.

1.2 DEFINITIONS

A. BAS: Building Automation System.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories, a schedule documenting radiated, inlet, and discharge sound pressure levels per octave band center frequency at the operating conditions scheduled.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection and associated values.

1. Wiring Diagrams: Power, signal, and controls wiring.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension components.

2. Structural members to which fan coil units will be attached.

3. Method of attaching hangers to building structure.

4. Size and location of initial access modules for acoustical tile.

5. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of fan coil unit indicated.

F. Manufacturer Seismic Qualification Certification: Submit certification that fan coil units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls and filters.

I. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. ARI Compliance: Rated and tested in accordance with ARI Standard 440 “Room Fan Coil Units.”

E. UL listed and labeled in accordance with ANSI/UL Standard 880 - “Safety Standard for Fan Coil Units.”

F. All units must be tested in accordance with ARI 350 “Sound rating of Non-Ducted indoor Air-Conditioning Equipment”

1.5 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

C. Specific configuration of the supply and return ductwork and piping at each unit has been indicated on the drawings. If the configuration of the units furnished on the project differs from that indicated on the drawings (whether or not the units furnished are the specific units or an acceptable substitute), it shall be the contractor's responsibility to modify ductwork, piping, etc., as required to accommodate the actual configuration of units furnished on the project.

1.6 WARRANTY

A. Furnish minimum 1 year from date of final acceptance.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan coil unit Filters: Furnish two spare filters for each filter installed.

2. Fan Belts: Furnish two spare fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer shall be responsible for examining applications of each type of unit to assure that each will operate properly in the intended application.

B. Unit sizes are shown as selected in accordance with the principles set forth in the ASHRAE Guide and Manufacturer's literature.

C. All items of a given type shall be the products of the same manufacturer.

2.2 FAN COIL UNITS

Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

A. Manufacturers

1. **Carrier Corporation.**

2. **Trane.**

3. **Johnson Controls**.

B. Description: Factory-packaged, completely assembled and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1-inch (25-mm) thick, foil-covered, closed-cell foam complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1

D. Main and Auxiliary Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1

E. Chassis: 18 gauge galvanized steel casing withstanding 125 hour salt spray test per ASTM B117. Floor-mounted units shall have leveling screws.

F. Cabinet: 18 gauge galvanized steel casing withstanding 125 hour salt spray test per ASTM B117 with baked-enamel finish in manufacturer's custom paint color as selected by Architect.

1. Vertical Unit Front Panels: Removable, steel, with steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.

2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.

3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille and louvered- or panel-type return grille; color as selected by Architect from manufacturer's custom colors. Return grille shall provide maintenance access to fan coil unit.

4. Steel recessing flanges for recessing fan coil units into ceiling or wall.

G. Outdoor-Air Wall Box: Minimum 0.1265-inch- thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.

1. Louver Configuration: Horizontal, rain-resistant louver.

2. Louver Material: Aluminum.

3. Bird Screen: 0.5-inch mesh screen on interior side of louver.

4. Decorative Grille: On outside of intake.

5. Finish: Anodized aluminum, color as selected by Architect from manufacturer's custom colors.

H. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic, modulating actuators.

I. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Recirculating fan coil units require pre-filter and MERV 13 final filter,

2. Fan coil units with outside air connections refer to Division 23 Section 23 40 00 “HVAC Air Cleaning Devices” for requirements that include activated carbon filters.

J. Hydronic Coils: 0.375 in. diameter, copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

K. Fan and Motor:

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Galvanized steel or aluminum wheels, and aluminum, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated, variable speed resiliently mounted on removable motor board. Comply with electrical equipment requirements of Division 23 Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

3. Wiring Termination: Connect motor to chassis wiring with twist lock plug connection.

L. Unit Control Box: Integral unit cabinet to include:

1. Fan starter and electric heating coil circuit breakers.

2. Disconnect switches

3. Control circuit transformer for 24 volt control circuit, fused on primary and secondary sides.

4. All controls factory installed and prewired.

5. Single point power entry

6. Numbered Terminal strips.

M. Factory, Hydronic Piping Package: ASTM B88, Type L (ASTM B88M, Type B) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Two-way, modulating control valve for dual-temperature coil.

2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F Tag hose kits to equipment designations.
   a. Length: 36 inches.
   b. Minimum Diameter: Equal to fan coil unit connection size.

3. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600 psig minimum CWP rating and blowout-proof stem.

4. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125 psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

5. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300 psig working pressure at 250 deg F with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig

6. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125 psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 0.5inch hose-end, full-port, ball-type blowdown valve in drain connection.

7. Wrought-Copper Unions: ASME B16.22.

8. Risers: ASTM B88, Type L (ASTM B88M, Type B) copper pipe with hose and ball valve for system flushing.

N. Control devices and operational sequences are specified in Division 25 Sections "Terminal Building Automation System".

O. Basic Unit Controls:

1. Control voltage transformer.

2. Wall-mounting thermostat with the following features:
   a. Heat-cool-off switch.
   b. Fan on-auto switch.
   c. Fan-speed switch.
   d. Automatic changeover.
   e. Adjustable dead band.
   f. Exposed set point.
   g. Exposed indication.
   h. Degree F indication.

3. Wall-mounting temperature sensor.

4. Unoccupied-period-override push button.

5. Data entry and access port.
   a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
   b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

P. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

2. Unoccupied Period Override Operation: Two hours.

3. Unit Supply-Air Fan Operation:
   a. Occupied Periods: Fan runs continuously.
   b. Unoccupied Periods: Fan cycles to maintain room setback temperature.

4. Dual-Temperature Hydronic-Coil Operation:
   a. Occupied Periods: When chilled water is available, modulate control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
   b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, modulate control valve if room temperature falls below thermostat setback temperature.

5. Reheat-Coil Operation:
   a. Occupied Periods:
      (1) Heating Operations: Modulate control valve to provide heating if room temperature falls below thermostat set point.
   b. Unoccupied Periods: Start fan and modulate control valve if room temperature falls below setback temperature. Humidity control is not available.

6. Outdoor-Air Damper Operation:
   a. Occupied Periods:
      (1) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below thermostat set point, position damper to fixed minimum position.
      (2) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
   b. Unoccupied Periods: Close damper.

7. Controller shall have volatile-memory backup.

Q. BAS Interface Requirements:

1. Interface relay for scheduled operation.

2. Interface relay to provide indication of fault at the central workstation.

3. Provide BACnet interface for central BAS workstation for the following functions:
   a. Adjust set points.
   b. Fan coil unit start, stop, and operating status.
   c. Data inquiry, including outdoor-air damper position, supply- and room-air temperature.
   d. Occupied and unoccupied schedules.

R. Electrical Connection: Factory wire motors and controls for a single electrical connection.

S. Capacities and Characteristics: As scheduled on drawings.

PART 3 - EXECUTION

Examine areas to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

3.1 STORAGE AND HANDLING

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

B. All fan coil units shall be received and stored on the job site with the wooden shipping skids in place. Under no condition shall the units be stored on such a way that metal components are in direct contact with the ground.

C. Unit delivery shall be coordinated with building construction and units shall be delivered to the job site just prior to their installation. Cover air handling units stored on the job site with 6 mil polyethylene sheet, taped in place, to protect the units from damage and the weather. Units that receive water damage due to improper handling or storage shall be removed from the site and new ones furnished at no additional charge to LAWA.

3.2 INSTALLATION

A. Examine areas to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Install fan coil units level and plumb.

E. Install fan coil units to comply with NFPA 90A.

F. Suspend fan coil units from structure with elastomeric hangers and at least four 3/8 inch) galvanized threaded support rods. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

G. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

H. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.

3. Connect condensate drain to full size but not less than 3/4 inch indirect waste.
   a. Install condensate trap of adequate depth to seal against the pressure of fan.
   b. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL1995 for duct connections.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of LAWA final acceptance, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

C. Engage a factory-authorized service representative to train LAWA Facilities and Maintenance personnel to adjust, operate, and maintain fan coil units.

3.7 TRAINING

A. See LAWA DCH Guide Specification 01 79 00 “Demonstration and Training” for demonstration and training requirements.

B. Provide minimum of 8 hours each (3 shifts) of classroom and hands on training to LAWA Facilities and Maintenance personnel.

END OF SECTION 23 82 19