SEATTLE ARTCC
AUTOMATION WING REHABILITATION
SECOND FLOOR AND ATTIC

SPECIFICATIONS

Volume II

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ATO Tech Ops Engineering Services
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DIVISION 15

MECHANICAL SYSTEMS

SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Grout.
4. Mechanical demolition.
5. Equipment installation requirements common to equipment sections.
6. Painting and finishing.
7. Supports and anchorages.
8. For grounding of mechanical materials, see electrical Sections.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.

1.3 REFERENCE STANDARDS

A. American Conference of Governmental Industrial Hygienists (ACGIH)

1. 1999 TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents."
2. VS-90-02 Welding Ventilation Movable Exhaust Hoods.

B. American Society of Mechanical Engineers (ASME)

1. A13.1: Scheme for the Identification of Piping Systems.
2. B1.20.1: Pipe Threads, General Purpose (Inch)
3. B16.20: Metallic Gaskets for Pipe Flanges-Ring-Joint, Spiral-Wound, and Jacketed.
4. B16.21: Nonmetallic Flat Gaskets for Pipe Flanges.
5. B18.21: Square and Hex Bolts and Screws Inch Series.
6. B31: Manual for Determining the Remaining Strength of Corroded Pipelines.
7. ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

C. American Society for Testing and Materials (ASTM)

1. A47: Specification for Ferritic Malleable Iron Castings.
2. A53: Specification for Pipe, Steel, Black, and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. A126: Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
4. A536: Specification for Ductile Iron Castings.
5. B32: Specification for Solder Metal.
6. B88: Specification for seamless copper tube.
7. B306: Specification for copper drainage tube.
8. C564: Specification for rubber gaskets for cast iron soil pipe and fittings.
9. C1107: Specification for package dry, hydraulic-cement grout.
10. D709: Specification for Laminated Thermosetting Materials.
11. D2000: Standard classification system for rubber projects.

D. American Welding Society (AWS)

1. D1.1: Structural Welding Code Steel.
2. D10.12: Recommended Practices and Procedures for Welding Low Carbon Steel.

E. American Water Works Association (AWWA)

1. C110: Ductile Iron and Gray Iron Fitting, 3 in. through 48 in. for Water and other Liquids.
2. C111: Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
3. C151: Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.

1.4 SUBMITTALS

A. Prepare submittal data in accordance with procedures of Section 01300, “Submittals.”

B. Product Data: For the following:

1. Piping materials
2. Dielectric fittings.
3. Grout

C. Prepare coordination drawings to a 1/4-inch scale. Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Show where sequence and coordination of installations are important to the efficient flow of the Work. Show proposed locations of piping, ductwork, equipment, and materials. Include the following:

1. Planned piping layout, including valve and specialty locations and valve stem movement.
2. Planned duct systems layout, including elbow radii and duct accessories.
3. Clearances for installing and maintaining insulation.
4. Clearances for servicing and maintaining equipment include space for equipment disassembly required for periodic maintenance.
5. Equipment service connections and support details.
6. Exterior wall, floor, and foundation penetrations.
7. Fire-rated wall and floor penetrations.
8. Sizes and location of required concrete pads and bases.
9. Access panel and access door locations.
10. Scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
11. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
12. Drawings detailing fabrication and installation for metal supports and anchorage for mechanical materials and equipment. Supports and anchorage shall include vibration isolation and seismic bracing per Division 15 Section “Mechanical Vibration and Seismic Controls.”

D. Welder certificates signed by Contractor certifying that welders comply with requirements specified below.

E. Material Safety Data Sheets (MSDS): Submit MSDS for adhesives, paints, solvents, fireproofing, sealants and any other product which may cause acute or chronic health or safety effects to facility occupants.

F. Temporary HVAC Plan: Submit plan which defines how temporary local heating, cooling and ventilation will be provided. The plan must be approved by COTR prior to start of work.

G. Prepare and distribute operations and maintenance data as specified in Section 01782, “Operation and Maintenance Manual Data.”

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

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

C. Characteristics for Mechanical Equipment: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. If larger equipment is approved, no additional costs shall be approved for these increases. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements.

D. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Provide covered shelters for storage of all mechanical equipment. Cover all equipment with polyethylene covering.

1.7 COORDINATION

A. Layout Work from building and property lines and benchmarks provided, verify, and be responsible for the correctness of measurements in connection with Work. Change made to major overall dimensions shown which affect the physical size, shape, or location of any part of the Work, whether due to field check or changes due to the use of equipment of a manufacturer other than that used as a basis of design shall cause no interference with other Work.

B. Examine the Drawings of other trades. Cooperate and coordinate with other trades to insure that the Work can be installed properly as designed and planned without interference with other work or delay. Where interferences may occur and departures from arrangements shown are required, consult with other trades involved. Come to an agreement as to changes, locations, and elevations. Furnish all necessary templates, patterns, measurements, etc., for installation and for the purpose of making adjoining work conform. Furnish setting plans and shop details to other trades as required.

C. Investigate the structural and finish conditions affecting the Work. Offsets, bends or other items required may not be shown due to the small scale of the Drawings; provide such offsets, bends or other items as required to meet structural or finish condition.

D. Coordinate and be responsible for the required clearances in shafts, chases, double partitions and suspended ceilings. Coordinate and cooperate with the trades responsible for constructing such spaces, together with other trades sharing such spaces, and advise other trades of the requirements of the Work. Immediately submit for review large-scale composite Drawings showing space requirements that exceed those shown.

E. Prepare large scale composite working Drawings and details as specified in Section 15891, "Metal Ductwork" 1/4 inch = 1 ft -0 inch minimum scale for all mechanical rooms; and including such section views and details as are necessary to clearly show how the systems are to be installed in relation to the work of other trades. Include double line piping and double line ductwork, conduit, motor control center and starters, penetrations, and openings. Include detailed Drawings of pipe anchors showing all forces including seismic restriction and items listed under "Submittals". Issue such Drawings to the other trades for coordination of their work. Finished Drawings shall be signed off by the Contractor and mechanical and electrical installers. Where such Drawings show deviations from the Contract Drawings or conflict with other trades, detail and submit such deviation or conflicts to the COTR for review.

F. If work is installed before coordinating with other trades so as to cause interference with the work of other trades, or so as not to provide proper access for maintenance or repair, make necessary changes to correct the condition at no cost to the government.

G. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

H. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

I. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

J. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

K. Coordinate connection of electrical services.

L. Coordinate installation of identifying devices after completing covering and painting where devices are applied to surfaces. Install identifying devices prior to installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

C. Grooved mechanical joint pipes and valves are permitted only for fire protection piping. Grooved mechanical joint pipes and valves will not be accepted for chilled water, hot water, domestic cold water, industrial water, condensate drain, or domestic hot water piping.

2.3 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, NBR 1/8-inch minimum thickness. Pressure rating (psi) multiplied by temperature rating (deg F) shall be minimum of 320,000.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Full-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   c. Known Acceptable Source: Garlock “Blue-Guard” Style 3000.

2. AWWA C110, rubber, face, 1/8 inch thick, full-face, unless otherwise indicated: For ductile Iron flanges.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Known Acceptable Source:

a. Watts Industries, Inc.; Water Products Div.
b. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Known Acceptable Source:

a. Epco Sales, Inc.
b. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Known Acceptable Source:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Known Acceptable Source:

a. Calpico, Inc.
b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F .

1. Known Acceptable Source:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.

2.5 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

A. Refer to Division 1 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

D. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.

E. Repair cut surfaces to match adjacent surfaces.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction

loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes. Where slope is not indicated, install mains with a slope of not less than 1/8 inch in 10 feet, in direction of flow, upward in the case of water under pressure, whenever possible. Branches shall be pitched to drain. Changes in size of horizontal mains shall be made by means of eccentric reducers placed at least 18 inches beyond the connection from the main with the top of the pipe flat. Install drains at low points in mains, risers, and branch lines; consisting of a tee fitting, 3/4-inch ball valve, and short 3/4-inch threaded nipple and cap.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation plus 1 inch clearance around insulation.

K. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

L. Install couplings according to manufacturer's printed instructions.

M. Select system components with pressure rating equal to or greater than system operating pressure.

N. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, stamped-steel type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamp-steel type with polished chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
   f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw or spring clips.
   g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type set screw or spring clips.

h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:

a. Chrome-Plated Piping: Split-casting, stamped-steel with chrome-plated finish.
b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw or spring clips.
f. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

O. Sleeves are not required for core-drilled holes.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07270 "Fire Stopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article. Provide local ventilation in conformance with ACGIH Print VS-90-02

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
5. Ferrous metal piping located overhead in electronic equipment areas shall have welded joints.
6. Provide seismic protection in accordance with Section 15070, “Mechanical Vibration and Seismic Controls”.
7. Provide flanged valves installed for future connections with blind flanges. Screwed valves installed for future connections shall be plugged with a threaded brass plug.
8. Provide flexible pipe connectors on chilled water and hot water piping at the building expansion joints and air handling unit coil connections.
9. Welded connections for overhead piping above critical spaces: Where indicated on plans, piping joints shall be welded. Screwed and flanged connections will only be accepted for valves, strainers and miscellaneous devices required at each piece of equipment. Piping connections in the attic mechanical room are not considered overhead piping since there is a concrete slab in the room. Provide a drip pan under piping as indicated on the plans.

3.5 PIPING TESTING

A. Piping systems shall be tested and receive approval from the COTR before acceptance. Piping shall be tested before covering and concealing. Tests shall be conducted in the presence of the COTR, and notice shall be given not less than 3 days in advance of tests. Instruments, facilities, and labor required to conduct tests shall be furnished by the Contractor. Test instruments and

equipment shall be checked for capability and calibration before each use and shall be adjusted to required capacity and accuracy where necessary. Submit written report for each test to COTR.

1. Piping shall be tested with compressed air prior to hydrostatic testing to minimize the possibility of a leak causing damage to the facility or equipment located within the facility. Provide air compressor and all required test equipment. Air test shall be at a minimum of 40 psi for not less than two hours during which time all joints shall be inspected for leaks. Components such as pumps or valves not designed to operate under test pressures shall be removed or blocked from the system during tests and shall be reinstalled or unblocked after tests. Blank-off or replace with spool pieces, instruments, gages, equipment, safety or relief valves rated at pressure lower than test pressure during testing. Test and adjust alarms for satisfactory operating conditions.
2. Piping shall be hydrostatically tested at the pressures specified in Paragraph 3.13 of this Section. Components such as pumps or valves not designed to operate under test pressures shall be removed or blocked from the system during tests and shall be reinstalled or unblocked after tests. Blank-off or replace with spool pieces, instruments, gages, equipment, safety or relief valves rated at pressure lower than test pressure during testing. Test and adjust alarms for satisfactory operation conditions.
3. Hydrostatic tests shall be performed and shall be held with no leakage for not less than four hours during which time all joints shall be inspected for leaks. Systems and test pressures shall be as indicated in Paragraph 3.13 of this Section. After satisfactory completion of pressure tests, but before permanently connecting equipment, clean equipment and blow out the piping for sufficient length of time to ensure the interior is free of any foreign matter. Make adjustments, repairs, alterations and corrections, to meet specified test results. Inform COTR 48 hours in advance to witness the cleaning procedure.

    a. Correct defects disclosed by tests or inspection and replace defective parts, at no additional cost to Government. In replacing defective parts, use only new material; in the case of pipe, replace with the same length as the defective piece.
    b. Caulking of screwed joints or peening of welds is not acceptable. After defects have been corrected and parts replaced, retest until the system meets specified pressures.
    c. Test and adjust parts to specified pressures.
    d. Test and set safety and relief valves to specified relief pressure.
    e. After installation, test and adjust gages, thermometers, meters, and other instruments to ensure accurate operation and calibration.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment in accordance with approved shop drawings and approved submittal data.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment to allow right of way for piping installed at required slope.

3.7 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 CONCRETE BASES

A. Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

B. Housekeeping pads shall be coordinated with Division 15 Section, “Mechanical Vibration and Seismic Controls” and shall be sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost vibration isolator/seismic snubber anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

C. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1 and GIH Print VS-90-02.

3.10 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout in accordance with manufacturer's printed instructions.

3.11 TEMPORARY HVAC AND LOCAL VENTILATION

A. Provide local ventilation during construction for any activity, which produces vapors, gases, odors, dust, fumes, etc. Air shall be exhausted to the exterior of the building. Provide ventilation for welding operations and for the application or use of adhesives, paints, solvents, fireproofing, sealants or any other product, which may cause acute or chronic health or safety effects to facility occupants. Ventilation shall comply with Occupational Safety and Health Administration (OSHA) and American Conference of Government Industrial Hygienists (ACGIH) requirements. The ventilation shall maintain the dust, gas, odor, fume, and vapor concentrations below the OSHA and ACGIH exposure limits as defined on the product MSDS and in "1999 TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents."

B. Areas of the facility served by the equipment that is replaced may be occupied during construction.

C. Provide temporary heating and cooling as required to maintain a minimum space temperature between 70 and 78 degrees Fahrenheit within the area affected by the Work. Comply with applicable NFPA and OSHA requirements for partially occupied buildings under constructions.

3.12 PIPE AND PIPE FITTINGS, SCHEDULES

A. General:

Item	Size (inches)	Description
Pipe joints	2” and smaller (Type L Copper)	Solder joint, or flared tube type as indicated
Pipe joints	2-1/2” and larger (Black Steel)	Butt welded or flanged
Branch connections (ferrous metal)	Same as line size, typically;	Straight tees
	At Reducing branches	Reducing outlet tees shall be used
Flanges (bored to suit pipe)	Typically, except as noted below	Weld neck, with raised face
	Where mated to valves or equipment having flat face flanged connection	Weld neck with flat face. Flange shall match psi rating of equipment flange
Gaskets	2-1/2" and larger flanged connection	Refer to paragraph 2.3.B this section.
Bolting materials	Where both flanges are raised face steel	ASTM A193, Grade B7, studs with ASTM A194, Grade 2, or 2H heavy hex nuts. ANSI B1.1 course thread series Class 2 fit.
	Where one or both flanges are flat faced	ASTM A307, Grade B, machine bolts and nuts.
Thread compound and joint lubricant		Teflon tape
Dielectric Unions	Where ferrous and nonferrous materials are connected	Epco nut or flange type unions with insulators and gaskets to suit requirements

3.13 INDEX OF SYSTEMS AND SERVICES

System or Service	Line Symbol	Maximum Operating Temperature (degrees F)	Maximum Operating Pressure psig	Spec. Section	Hydrostatic Test Pressure psig
Cold Water (potable)	CW	Ambient	90	15410	135
Hot Water (potable)	HW	140	90	15410	135
Chilled Water Supply	CHS	Ambient	80	15180	120
Chilled Water Return	CHR	Ambient	80	15180	120
Heating Hot Water Supply	HS	185	70	15180	105
Heating Hot Water Return	HR	185	70	15180	105
Drain (condensate)	CD	120	Atmosphere	15410	10
Vent	V	Ambient	Atmosphere	15410	10
Sanitary Soil and Waste	SAN	Ambient	Atmosphere	15410	10
Fire Protection	F	Ambient	90	15325	135

END OF SECTION 15050

SECTION 15070 - MECHANICAL VIBRATION AND SEISMIC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Elastomeric Isolator Pads.
2. Spring Hangers.
3. Spring hangers with vertical-limit stops.
4. Thrust Limits.
5. Restrained Spring Isolators.
6. Restraining Cables.
7. Seismic Rod Clamps.

B. Related Sections include the following:

1. Section 15145 "Hanger and Supports" for equipment supports.

1.2 DEFINITIONS

A. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double-sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead equipment are not acceptable on this project as seismic anchor points.

B. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe or duct.

C. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe or duct.

D. OSHPD: Office of Statewide Health Planning & Development for the State of California. OSHPD assigns a unique anchorage preapproval "R" number to each seismic restraint it tests. The number describes a specific device applied as tested.

1.3 PERFORMANCE REQUIREMENTS

A. Mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections

B. Facility is an "essential" air traffic control facility (Occupancy Category IV per IBC 2006). Design mechanical equipment and systems bracing, and anchorage per International Building Code (IBC 2006), ASCE 7-02 and the SMACNA Seismic Restraint Manual (Second Edition). The most stringent shall govern. The requirements for seismic protection measures to be applied to mechanical equipment and systems (including ductwork and piping) specified herein are in addition to any other items called for in other Sections of the Specifications. Provide seismic bracing for equipment and systems (including ductwork and piping) within the project area. All seismic calculations, designs, and selections shall be performed, stamped, and submitted by a qualified licensed Professional Engineer hired by the general contractor. The qualified licensed Professional Engineer shall coordinate with the mechanical subcontractor for shop drawings, mechanical equipment, and actual installation conditions. For IBC 2006 calculations, the designer shall use a component importance factor, I_P, of 1.0 for AHU's, VAV terminal units, exhaust fans, and ductwork, and a component importance factor, I_P, of 1.5 for hydronic piping. Licensed professional engineer shall determine Seismic Design Category per IBC 2006.

1.4 SUBMITTALS

A. Product Data: Include load deflection curves for each vibration isolation device.

B. Shop Drawings: Signed and sealed by a qualified Licensed Professional Engineer experienced in seismic restraint design and installation. Include the following:

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases. The seismic restraint design shall clearly indicate the attachment points to the building structure and all design forces (in X, Y, and Z direction) at the attachment points. The seismic restraint design shall be based on actual equipment data (dimensions, weight, center of gravity, etc.) obtained from submittals or the equipment manufacturers. Analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure. Seismic restraint devices shall be designed to accept without failure the calculated forces.
2. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

C. Welding certificates.

D. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

   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. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Prepare and distribute operations and maintenance data as specified in Section 01872, "Operation and Maintenance Manual Data."

1.5 QUALITY ASSURANCE

A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage pre-approval "R" number, from OSHPD or another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.

B. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

C. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the FAA. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

1. B-Line Systems, Inc.
2. Mason Industries, Inc.
3. Kinetics Noise Control, Inc.

B. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in multiple layers, molded with a nonslip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Bridge-bearing neoprene, complying with AASHTO M 251.
2. Durometer Rating: As required for size of pad selected to support equipment.
3. Number of Layers: 2.

C. Spring Hangers: Combination coil-spring and elastomeric-insert hanger.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene, minimum of 1-1/4-inch thick, mounted at top of frame. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Known Acceptable Source: Mason Industries Type 30N.

D. Spring Hangers with vertical limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene, minimum of 1-1/4 inch thick, mounted at top of frame. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Hangers shall be pre-compressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Use where seismic bracing is provided at hanger.
8. Known Acceptable Source: Mason Industries Type PC30N.

E. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inchmovement at start and stop.

F. Restrained Spring Isolators (Air Handling Units): Vertically and laterally restrained spring isolator with constant free and operating height and replaceable neoprene snubbing elements.

1. Known Acceptable Source: Manufacturer – Kinetics Noise Control, Model FLS-2-500 (6 per AHU), 2” deflection. Mechanical contractor shall coordinate between AHU and spring isolator manufacturers for restrained spring isolator selections.

2.2 SEISMIC-RESTRAINT DEVICES

A. Known Acceptable Source:

1. B-Line Systems, Inc.
2. California Dynamics Corp.
3. Mason Industries, Inc.
4. Kinetics Noise Control, Inc

B. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 60, plus or minus 5, with a flat washer face.

C. Restraining Cables: Galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement. Cables must be pre-stretched to achieve a certified minimum modulus of elasticity. Cables must not be allowed to bend across sharp edges. Cable sizes may differ from SMACNA requirements as long as the cable break strength exceeds those listed in SMACNA Table 3-2.

1. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings.
2. Known Acceptable Source: Mason Industries Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam.

D. Anchor Bolts: Seismic-rated, drill-in, and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.

E. Seismic Rod Stiffeners: Used to provide additional support for threaded rod supports that will experience compressive force in a seismic event. Galvanized steel angle or 12 gage strut channel with minimum of 3 attachment clamps. Known acceptable source: B-line B22 channel with SC228 hanger rod stiffener assembly or SC-UB stiffener assembly.

F. Restrained Spring Isolators (Air Handling Units): Vertically and laterally restrained spring isolator with constant free and operating height and replaceable neoprene snubbing elements.
   1. The mechanical contractor shall coordinate with vibration and seismic engineers for the design of the external vibration isolation and external seismic protection of the AHU.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

   1. Powder coating on springs and housings.
   2. All hardware shall be electro-galvanized.
   3. Baked enamel for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

B. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. Do not install any equipment, piping, duct or conduit that makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions shall be brought to the COTR's attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the contractor's expense.

G. Bring to the COTR's attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.

H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.

I. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

1. Flanges of structural beams.
2. Upper truss cords in bar joist construction.
3. Cast in place inserts or wedge type drill-in concrete anchors.

J. Cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

K. Cable assemblies are installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

L. At locations where seismic restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with specification braces.

M. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight.

N. Locate isolation hangers as near to the overhead support structure as possible.

3.3 PIPING INSTALLATION

A. Horizontal pipe isolation: The first five pipe hangers in the supporting piping connected to each air handling unit shall spring hangers with vertical limit stop. Floor supported piping shall

rest on Elastomeric Isolator Pads. The first five isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install expansion joints.

B. Seismic Restraint of Piping: See equipment schedule below.

3.4 DUCTWORK INSTALLATION

A. Supply duct runs for a distance of 25-feet from the connected equipment shall be isolated from the building structure by means of spring isolators. Spring deflection shall be a minimum of 0.75 inch.

B. Duct runs having air velocity of 1500 fpm or more shall be isolated from the building structure by spring isolators. Spring deflection shall be a minimum of 0.75 inch.

C. Seismic Restraint of Ductwork: See equipment schedule below.

3.5 MISCELLANEOUS EQUIPMENT INSTALLATION

A. Wall mounted panels including direct digital control panels shall be mounted with anchors sized to support the weight of the panel. The anchors shall also resist the calculated seismic forces with a safety factor of 2.

B. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.

C. Install vibration isolators and seismic snubbers to isolate equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure. Combined vibration isolators and seismic snubbers are acceptable.

D. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.

E. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

F. Install resilient bolt isolation washers on equipment anchor bolts.

3.6 FIELD QUALITY CONTROL

A. Testing: Engage a qualified person to perform the following field quality-control testing:

B. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.
2. Isolator deflection.
3. Snubber minimum clearances.

C. Seismic Anchor Proof Test: Test 10 percent of concrete anchors used to seismically brace piping in accordance with SMACNA requirements. Test load and torque for wedge type anchors are listed on the mechanical sheets. Proof testing is not required for anchors used for any other purpose.

3.7 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.

D. Adjust active height of spring isolators.

E. Adjust snubbers according to manufacturer's written recommendations.

F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

G. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.8 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.9 DEMONSTRATION AND TRAINING

A. Demonstration and Training: Provide demonstration and training in accordance with Section 01820 “Demonstration and Training.”

3.10 EQUIPMENT ISOLATOR AND SEISMIC RESTRAINT SCHEDULES

Equipment Schedule	Vibration Isolation	Seismic Restraint
Air Handling Units,VAV Terminal Units, Exhaust Fans	Required – External Isolation	Design, furnish, and install seismic restraints in accordance with ASCE 7-02
Direct Digital Control Panels	Not Required	As Specified
Piping	As Specified	Design, furnish, and install seismic restraint for piping in accordance with ASCE 7-02 and the SMACNA Seismic Restraint Manual, whichever is more stringent.
Ductwork	As Specified	Design, furnish, and install seismic restraint for ductwork in accordance with ASCE 7-02 and the SMACNA Seismic Restraint Manual, whichever is more stringent.
Fire Protection Equipment and Piping	Not Required	Refer to NFPA 13

END OF SECTION 15070

SECTION 15100 - VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general duty valves common to several mechanical piping systems.

B. Grooved mechanical joint valves are permitted only for fire protection piping per Section 15325, "Automatic On/Off Fire Sprinkler System." Grooved mechanical joint valves will not be accepted for any other application.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)
1. B16.1: Cast Iron Pipe Flanges and Flanged Fittings.
2. B16.10: Face-to-Face and End-to-End Dimensions of Valves.
3. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
4. B16.34: Valves - Flanged, Threaded, and Welding End.

B. American Society of Mechanical Engineers (ASME)
1. B1.20.1: Pipe Threads, General Purpose (Inch).
2. B16.1: Cast Iron Pipe Flanges and Flanged Fittings.
3. B16.5: Pipe Flanges and Flanged Fittings.
4. B31.1: Power Piping.
5. B31.9: Building Services Piping.
6. Section VIII Rules for Construction of Pressure Vessels.

C. American Society for Testing and Materials (ASTM)
1. A47: Specification for Ferritic Malleable Iron Castings.
2. A126: Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
3. A216: Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
4. A220: Specification for Pearlitic Malleable Iron.
5. A278: Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 deg F.
6. A536: Specification for Ductile Iron Castings.
7. B61: Specification for Steam or Valve Bronze Castings.
8. B62: Specification for Composition Bronze or Ounce Metal Castings.
9. B371: Specification for Copper-Zinc Silicon Alloy Rod.
10. B584: Specification for Copper Alloy Sand Castings for General Applications.

D. Manufacturers Standardization Society (MSS)
1. SP25: Marking System for Valves, Fittings, Flanges, and Unions.
2. SP45: Bypass and Drain Connections.
3. SP71: Cast Iron Swing Check Valves, Flanges and Thread Ends.
4. SP110: Ball Valves Threaded, Socket-Welded, Solder Joint, Grooved and Flared Ends.

1.3 SUBMITTALS

A. Prepare submittal data in accordance with procedures of Division 1 Section, "Submittals."

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

C. Prepare and distribute operations and maintenance data as specified in Division 1 Section, "Operation and Maintenance Manual Data."

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

C. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.
4. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use a sling to handle large valves. Rig to avoid damage to exposed parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Valves: Provide valves from the valve table indicated in the Index of Systems and Services for each piping system.

B. General: Furnish valves of each type, made by one manufacturer. Provide stem extensions for valves installed in insulated piping.

C. Unless otherwise indicated, valves installed in connection with mechanical piping shall comply with the following and as specified in Division 15 Section, "Basic Mechanical Material and Methods":

1. Furnish one make throughout the project. All valves of a given type shall be provided by the same manufacturer.
2. Properly pack stems.
3. Mark each valve at the factory with the following minimum information, engraved, stamped, or cast on each valve or metal tag permanently attached to the valve indicating manufacturer's name, catalog or figure no., size and pressure class and arrows to indicate direction of flow on check, globe, angle and eccentric plug valves.
4. Valves shall be furnished with TFE, tetrafluoroethylene coating (or TEFLON trademark coating) on seats and gaskets. Packing materials shall be impregnated with material to prevent sticking or freezing of valve operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valves interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions.

B. Coordinate piping installation and specialties arrangement requirements with schematics on Drawings and requirements specified in hydronic water system Specifications.

C. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

D. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

E. Locate valves for easy access and provide separate support where necessary.

F. Install valves in horizontal piping with stem at or above the center of the pipe.

G. Install valves in a position to allow full stem movement.

H. Install check valves with flow arrow pointed in direction of system flow.

I. Install balance valves on each hydronic terminal and as indicated. After hydronic system balancing has been completed, mark each balance valve with stripe of yellow paint across body and stop plate to permanently mark final balanced position.

J. Strainers: Install Y type strainers in accordance with the manufacturers instructions, and the following:
   1. Install strainers same size as pipe;
   2. Install nipple and shut off valve in strainer blow down; same size as blow down;
   3. Provide drain line from shut off valve to plumbing drain; and
   4. Install strainers as indicated and upstream of the temperature control valves, if integral strainer is not provided.

3.3 SOLDERED CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

F. Apply heat evenly to outside of valve around joint until solder melts on contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench to manufacturer's recommended torque values.
   1. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.5 VALVE END SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

B. Copper Tube Size, 2 Inches and Smaller: Solder ends, except provide threaded ends for heating hot water service.

C. Steel Pipe Sizes, 2 Inches and Smaller: Threaded.

D. Steel Pipe Sizes, 2-1/2 Inches and Larger: Flanged.

3.6 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

B. Cleaning: Clean factory finished surfaces, and repairs marred or scratched surfaces.

3.7 INDEX OF SYSTEMS AND SERVICES

System or Service	Line Symbol	Maximum Operating Temperature (^{o}F)	Valve Table	Hydrostatic Test Pressure psig
Cold Water (potable)	CW	Ambient	I	135
Hot Water (potable)	HW	140	I	135
Chilled Water Supply	CHS	Ambient	II	120
Chilled Water Return	CHR	Ambient	II	120
Heating Hot Water Supply	HS	185	II	105
Heating Hot Water Return	HR	185	II	105
Fire Protection	F	Ambient	See Section 15325	120

3.8 VALVE TABLE I

Item	Size (inches)	Description
Drain	1/2	Body, bronze; Bonnet, screwed type; Disc, composition; End prep, differential, female IPS 3/4 inch hose; Rated for non-shock pressure of 150 psig at 200 F; Handle, standard open rim handweel; Recommended service: Water
Ball	2 and smaller	MSS SP-110, Pressure rated to 150 WSP, 400 psi WOG, ASTM B124 brass 3-piece, full port, body designed to provide in-line maintenance; Ball, electroless nickel-plated brass; Seats, Carbon/Glass reinforced PTFE Durafill; Stem, B16 brass; Packing, reinforced PTFE with stem thrust bearing; End prep, solder; Handle, vinyl insulated zinc plated carbon steel; Recommended service: Water
Check	2 and smaller	MSS SP-80 Class 150, 300-psi CWP, Y pattern, swing type; Body, bronze, ASTM B62 alloy C83600; Cap, screwed type, bronze, ASTM B61 alloy C92200; Disc, hinge type, brass, ASTM B16, alloy H02 for 1/4 inch - 3/4 inch or ASTM B61 alloy C92200 for 1 inch - 2 inches; Hinge pin, 18-8 stainless steel; End prep, solder joint; Recommended service: Water
Backflow Preventor	2 and smaller	Body, bronze; Bonnet, integral ; Body unions 175 psi Rated. ASSE Standard 1013 quarter turn, full port resilient seated, bronze ball valve, internal polymer coating
END OF TABLE		

1. Service: See Index of Systems and Services

3.9 VALVE TABLE II

Item	Size (inches)	Description
Ball	2 and smaller	MSS SP-110, Pressure rated to 150 WSP, 400 psi WOG, ASTM B124 brass 3-piece full port body designed to provide in-line maintenance; Ball, 316 stainless steel; Seats, Carbon/Glass reinforced PTFE Durafill; Stem, 316 stainless steel; Packing, reinforced PTFE with stem thrust bearing; End prep, NPT; Handle, vinyl insulated zinc plated carbon steel; Recommended service: Water

Item	Size (inches)	Description
Ball	2-1/2 and larger	2-piece, full port, cast iron body (ASTM A126 Class B), 125 psi WSP rating, 200 psi CWP rating, quarter-turn open or close operation, 304 stainless steel ball and stem, PTFE seat, packing, and gaskets Known acceptable source: Watts Regulator ball valve (model G4000M1)
Check	2 and smaller	MSS SP-80 Class 125, 200-psi CWP, Y pattern, swing type; Body, bronze, ASTM B62 alloy C83600; Cap, screwed type, bronze, ASTM B61 alloy C92200; Disc, hinge type, brass, ASTM B16, alloy H02 for 1/4 inch - 3/4 inch or ASTM B61 alloy C92200 for 1 inch - 2 inches; Hinge pin, 18-8 stainless steel; Recommended service: Water
Check	2-1/2 and larger	Body and bonnet, carbon steel, ASTM A126 Grade WCB; Bolted type bonnet; Disk, Stainless steel with 13% chromium; Hinge pin, 410 stainless steel; Swing type disc; Rated for 285 psi at 100 F; flanged end prep; Standard trim
Balancing	1/2 through 2	Valve internal flow measurement piece shall be a brass venturi machined to attain +/- 1%. Body: ASTM brass alloy housing, rated at no less than 400 PSI/250 degrees F. Valves shall also include an isolation ball valve with equal percentage port and memory stop, a venturi measurement piece, dual pressure/temperature test valves for signal reading, and a union end which will accept various pieces. Acceptable Source: Griswold QuickSet Manual Balancing Valve
Balancing	2-1/2 through 4	Valve internal flow measurement piece shall be machined to attain +/- 1% accuracy throughout its range. Body: Valves shall consist of a carbon steel SA-53 Grade B valve, with a carbon steel low loss venturi and a butterfly valve outlet, and memory stop; rated for 250PSI/230 degrees F. Valve shall be supplied with dual pressure/temperature test valves for signal reading. Acceptable Source: Griswold QuickSet Manual Balancing Valve

END OF TABLE

1. Service: See Index of System and Services.

END OF SECTION 15100

SECTION 15125 - PIPE EXPANSION JOINTS

PART 1 - GENERAL

1.1 SUMMARY

A. The contractor shall design, furnish, and install pipe expansion joints, guides, and anchors for mechanical piping systems in accordance with this section.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME)

1. Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
2. B18.10 -Track Bolts and Nuts.
3. B31.9 - Building Services Piping.

B. American Society for Testing and Materials (ASTM)

1. A36/36M - Standard Qualification for Carbon Structural Steel.
2. A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
3. A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
4. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
5. F844 - Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.

C. American Welding Society (AWS)

1. D1.1 - Structural Welding Code Steel.

D. Steel Structures Painting Council (SSPC)

1. PA1 - Paint Application Specification No. 1 Shop, Field, and Maintenance Painting.

1.3 PERFORMANCE REQUIREMENTS

A. The contractor shall design, furnish, and install pipe expansion joints, guides, and anchors for mechanical piping systems in accordance with this section.

B. Compatibility: Provide pipe expansion joints, pipe alignment guides, and pipe anchors suitable for piping system fluids, materials, working pressures, and temperatures.

C. Fabricate and install expansion and anchor system capable of sustaining forces generated by gravity, thermal movement, and seismic events.

D. Design and obtain approval from authority with jurisdiction, seismic restraints for pipe expansion joints and pipe anchor system.

1.4 SUBMITTALS

A. Product data for each type of pipe expansion joint and pipe alignment guide specified.

B. Pipe expansion joint schedule showing manufacturer's figure number, size, location, and features for each required expansion joint.

C. Assembly-type shop drawings for each type of pipe expansion joint, pipe alignment guide, and anchor, indicating dimensions, weights, required clearances, and methods of component assembly.

D. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the "Quality Assurance" Article.

E. Maintenance data for each type pipe expansion joint specified to include in the "Operating and Maintenance Manuals".

1.5 QUALITY ASSURANCE

A. Qualify welding processes and welding operators according to AWS D1.1 "Structural Welding Code--Steel."

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Qualify welding processes and welding operators according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

C. Licensed Engineer's Design Drawings and Calculations: Design and prepare drawings and calculations for seismic restraint of pipe expansion joints, pipe alignment guides, and pipe anchors. Include seal and signature of Registered Engineer certifying compliance with specifications.

PART 2 - PRODUCTS

2.1 PIPE EXPANSION JOINTS, GENERAL

A. Capability: Absorb 200 percent of maximum piping expansion between anchors.

2.2 EXPANSION JOINTS

A. Expansion and contraction as well as seismic motion shall be absorbed by a 60E Vee flexible hose configuration, or equivalent, capable of plus and minus 4" motion in all planes.

The 304 Stainless Steel Hose and Braid shall have a minimum free length and number of corrugation per foot, as shown in Table 1. Pressure ratings are as published, minimum. All flanged connectors shall have free floating flanges at each end to allow rotation into any position.

The Vee shall not be welded into the piping. Flanges, Threaded or Grooved fittings shall be used in the same sizes as specified throughout the project. Guiding and anchoring shall be installed as is recommended by the manufacturer.

Stainless assemblies shall be the SS 60E Vee, as manufactured by Mason Industries, Inc, or equal.

Size		Corrugations per		Live Length of Braid & Hose		Approximate Resistance for 4" (100mm) Displacement	
in	(mm)	foot	(meter)	in	(mm)	pounds	(kgs)
	15	108	354	14	350	20	9
3/4	20	94	308	15	375	20	9
1	25	84	276	16	400	25	11
1 1/4	30	74	243	17	425	25	11
1 1/2	35	70	230	19	475	40	18
2	50	68	223	20	500	40	18
2 1/2	65	56	290	22	550	50	23
3	75	54	177	24	600	50	23
4	100	32	105	26	650	80	36
5	125	30	98	30	750	80	36
6	150	29	95	33	825	100	45
8	200	26	85	36	900	200	91

10	250	25	82	42	1050	300	136
12	300	24	79	48	1200	400	181

2.3 PIPE ALIGNMENT GUIDES

A. Factory-fabricated cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base. Include two-section guiding spider that bolts tightly to the pipe.

1. Alignment Guide Lengths: As required for indicated travel.

2.4 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36, steel plates, shapes, and bars, black and galvanized.

B. Bolts and Nuts: ASME B18.10 or ASTM A183, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F844, steel, plain, flat washers.

D. Grout: ASTM C1107, Grade B, non-shrink, nonmetallic.

1. Characteristics include post-hardening volume-adjusting dry hydraulic-cement-type grout that is non-staining, non-corrosive, non-gaseous and is recommended for both interior and exterior applications.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Water: Potable.
4. Packaging: Premixed and factory-packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions under which pipe expansion joints, pipe alignment guides, and pipe anchors are to be installed. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE EXPANSION JOINT INSTALLATION

A. Install pipe expansion joints according to manufacturer's written instructions.

B. Align expansion joints to avoid end-loading and torsional stress.

3.3 FABRICATED-TYPE PIPE EXPANSION COMPENSATION INSTALLATION

A. Install pipe expansion loops cold-sprung in tension or compression as required to absorb 50 percent of total compression or tension that will be produced during anticipated change in temperature.

3.4 PIPE ALIGNMENT GUIDE INSTALLATION

A. Install pipe alignment guides on piping and elsewhere as indicated.

B. Secure pipe alignment guides to building substrate.

3.5 PIPE ANCHOR INSTALLATION

A. Install pipe anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS D1.1.

C. Where pipe expansion joints are indicated, install pipe anchors according to expansion unit manufacturer's written instructions to control movement to compensators.

D. Pipe Anchor Spacings: Where not otherwise indicated, install pipe anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Preset anchors as required to accommodate both expansion and contraction of piping.

3.6 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint and paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.7 FIELD QUALITY CONTROL

A. Licensed Engineer's Installation Report: Prepare report covering installation of pipe expansion joints, pipe alignment guides, and pipe anchors. Include seal and signature of

Registered Engineer, licensed in the State of New Hampshire, certifying compliance with specifications.

END OF SECTION 15125

SECTION 15135 - METERS AND GAUGES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes meters and gauges used in mechanical systems.

1.2 REFERENCE STANDARDS

A. American Iron and Steel Institute (AISI)

1. Type 302 Stainless Steel Casings.
2. Type 316 Stainless Steel Construction, Stainless Steel Movements and Recalibrators.

B. American National Standard Institute (ANSI)

1. B40.1 Gauges - Pressure Indicating Dial Type Elastic Element.

C. American Society of Mechanical Engineers (ASME)

1. B40.1 Gauges, Pressure Indicating Dial Type Elastic Element.

D. Instrument Society of America (ISA)

1.3 SUBMITTALS

A. Product data for each type of meter, gauge, and fitting specified. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

B. Product certificates signed by manufacturers of meters and gauges certifying accuracy under specified operating conditions and compliance with specified requirements.

C. Maintenance data for inclusion in the "Operating and Maintenance Manuals"

1. Test plugs.
2. Thermometers.
3. Pressure gauges.

1.4 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

B. Design Criteria: The Drawings indicate types, sizes, capacities, ranges, profiles, connections, and dimensional requirements of meters and gauges and are based on the specific manufacturer types and models indicated. Review of other meters and gauges having equal performance characteristics shall be conducted, provided that deviations do not change the design concept or intended performance as judged by the COR. The burden of proof for equality of meters and gauges shall be by the Contractor.

PART 2 - PRODUCTS

2.1 BI-METAL DIAL THERMOMETERS

A. Description: Piping thermometers shall be bi-metal type, corrosion-resistant movements, with recalibrating adjustments with 5-1/4 inch dials with white face with black numerals, graduations and pointers, and AISI Type 302 stainless steel casings. All thermometers shall be installed with thermowells.

1. Provide thermometers with an accuracy within one percent of full scale range. Furnish an adjustable, indicator case with a flexible stainless steel bellows sealed at the case and stem connector. Use a 2 -1/2 inch stem length for all pipe sizes.
2. Thermometers installed on insulated lines or vessels shall be provided with an extension piece. Thermometers for chilled water service shall have a range of 25 degrees F. to 125 degrees F. Thermometers for heating hot water and domestic hot water service shall have a range of 20 degrees F. to 240 degrees F.

2.2 THERMOMETER WELLS

A. Description: Provide a thermowell at all thermometer locations. Thermowells shall be fitted with a plug and chain and conform to the requirements specified for thermometers.

B. Pressure Rating: Not less than piping system design pressure.

C. Stem Length: Thermowell stem length shall match thermometer stem lengths.

D. Extension for Insulated Piping: 2 inches nominal, but not less than thickness of insulation.

E. Threaded Cap Nut: With chain permanently fastened to well and cap.

2.3 PRESSURE GAUGES

A. Description: Provide pressure gauges where indicated and of suitable range for intended service. Pressure gauges shall comply with ANSI Standard B40.1, Grade 2A. Range shall be 0-100 psi. Piping to gauges on chilled water systems shall be insulated. Pressure gauges shall

be pulsation damper adjustable type. Pressure gauges shall have ½ inch NPT bottom connections.

B. Pressure gauges shall have 4-1/2 inch white dials with black numerals of the scale required with an accuracy within ½ of one percent of scale range. Gauges shall have phenolic cases, turret pattern, glass lens, Bourdon tube assemblies with AISI Type 316 stainless steel construction, stainless steel movements, and recalibrators.

2.4 PRESSURE GAUGE ACCESSORIES

A. Pressure gauges shall be provided with shutoff cocks and pressure snubbers.

2.5 TEST INSTRUMENTS

A. Furnish the following test instruments:

1. Four twelve inch glass-stem test thermometers with red reading mercury, two thermometers to read minus 40 degrees F to 120 degrees F. with one degree graduations, and two thermometers to read from 0 degrees to 220 degrees F. with two degree graduations.
2. Two 5-1/2 inch pocket test thermometers, reading from minus 30 degrees F. to plus 120 degrees F. with chromium plated brass case and pocket clip.
3. Two pocket test pressure gauges, reading from 0 to 100 pounds per square inch. Provide a 3 inch dial and brass case with cover.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. General: Provide thermometers where indicated and of suitable range for the intended service. Mount thermometers on the supply sides and return piping of all heating hot water and chilled water service for air handling units, and elsewhere as indicated.

1. Where thermometers are installed in insulated piping, use extension-neck separable sockets.
2. Provide thermowell at all thermometer locations. Thermowells shall be fitted with plug and chain and conform to the requirements specified for thermometers. Install thermowells at a 45 or 60 degree vertical angle to permit filling with conducting liquid for tests.

3.2 PRESSURE GAUGE APPLICATIONS

A. Provide pressure gauges, where indicated, of suitable range for the intended service. Mount common pressure gauge to read supply and return piping pressure of all heating hot water and chilled water service for air handling units, and elsewhere as indicated.

1. Provide pressure gauges with gauge pet cocks and pressure snubbers.
2. Piping to pressure gauges on chilled water system shall be insulated.

3.3 LOCAL TEST AND MEASUREMENT STATION APPLICATIONS

A. Provide and install where indicated local test and measurement stations. Test stations shall be 1/4 inch NPT fitting to receive either a temperature or pressure probe 1/8 inch O.D. The fitting shall be solid brass and rated at 1000 psi when located in heating hot water and chilled water piping to air handling units. The fitting shall have two valve cores. Fittings shall be furnished with color coded (blue for neoprene, yellow for nordel) and marked cap with gasket. Test plugs shall be provided as shown in accessible locations with clearance to allow for use of local tests instruments.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties.

B. Install meters and gauges adjacent to machines and equipment to allow servicing and maintenance.

3.5 ADJUSTING AND CLEANING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

C. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touch up paint.

END OF SECTION 15135

SECTION 15145 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment.

B. Related Sections include the following:

1. Division 15 Sections "Mechanical Vibration and Seismic Controls" for equipment seismic protection and vibration controls.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME).

1. Section IX: Qualification Standard for Welding and Brazing Procedures, Welders, Brazers and Welding and Brazing Operators.
2. B18.10: Track Bolts and Nuts.
3. B31.9: Building Services Piping.

B. American Society for Testing and Materials (ASTM)

1. A36: Specification for Carbon Structural Steel.
2. A123: Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. A183: Specification for Carbon Steel Track Bolts and Nuts.
4. A307: Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
5. A563: Specification for Carbon and Alloy Steel Nuts
6. A570: Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
7. A780: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
8. B633: Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
9. F844: Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.

C. American Welding Society (AWS)

1. D1.1: Structural Welding Code Steel.

D. Manufacturers Standardization Society (MSS)

1. SP58: Pipe Hangers and Supports-Materials, Design and Manufacture.
2. SP69: Pipe Hangers and Supports-Selection and Application.
3. SP89: Pipe Hangers and Supports-Fabrication and Installation Practices.
4. SP90: Guidelines on Terminology for Pipe Hangers and Supports.

E. National Fire Protection Association (NFPA)

1. 13: Installation of Sprinkler Systems.

F. Steel Structures Painting Council (SSPC)

1. PA1: Paint Application Specification No. 1, Shop, Field, and Maintenance Painting.

1.4 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and water. Include deadweight loads, hydrostatic loads, thermal loads, and seismic loads.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and water.

C. Design seismic restraint hangers and supports for piping and equipment.

D. Design and obtain approval from COTR for seismic restraint hangers and supports for piping and equipment.

1.5 SUBMITTALS

A. Prepare submittal data in accordance with procedures of Division 1 Section, “Submittals.”

B. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

C. Shop Drawings: Signed and sealed by a qualified, Licensed Professional Engineer with a pipe hanger and support schedule showing manufacturer's Figure No., size, location, and features for each required pipe hanger and support. The manufacturer’s product data for each component shall be attached to this schedule. Include design calculations and indicate size and characteristics of components and fabrication details.

D. Welding Certificates: Copies of certificates for welding procedures and operators.

E. Prepare and distribute operations and maintenance data as specified in Division 1 Section, “Operation and Maintenance Manual Data.”

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified Licensed Professional Engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in at least one of the 50 states and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

C. Manufacturer's Standardization Society (MSS) Compliance: Comply with requirements of SP-58, SP-69, SP-89, and SP-90. Provide load calculations for hangers. Include deadweight loads, hydrostatic loads, thermal loads, and seismic loads. Refer to Division 15 Section, "Mechanical Vibration and Seismic Controls" for additional seismic load requirements.

D. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Pipe Hangers:

   a. Cooper B-Line Systems, Inc.

2. Channel Support Systems:

   a. Cooper B-Line Systems, Inc.

3. Thermal-Hanger Shield Inserts:

   a. Pipe Shields, Inc.

   b. Cooper B-Line Systems, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized or Electro-Plated Zinc Steel: For insulated piping and equipment without direct contact to piping or equipment. Entire component shall be coated with zinc. Pre-galvanized components and components manufactured after application of zinc coating are not acceptable.

2. Galvanized or Electro-Plated Zinc Steel, Nonmetallic Coatings: For non-insulated piping and equipment with direct contact to piping or equipment. Entire component shall be coated with zinc. Pre-galvanized components and components manufactured after application of zinc coating are not acceptable. Provide plastic or vinyl coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: Factory-fabricated components for field assembly shall comply with Metal Framing Manufacturer's Association Standard MFMA-1. Struts shall be ASTM 570, Grade 33 hot dip galvanized after fabrication steel in accordance with ASTM A123. Struts shall be minimum 12 gauge, with minimum height of 1 5/8 inches and 1 5/8 inch width. Actual size shall be selected for expected loads.

1. Galvanized Steel; No Coatings: Manufacturer's standard finish.
2. Galvanized Steel, Nonmetallic Coatings: Provide PVC, plastic, or vinyl coating for electrolytic protection where attachments are in direct contact with copper tubing.
3. Channel End Caps: Provide plastic end caps designed to protect personnel and clothing from sharp edges.
4. Known Acceptable Source: Cooper B-Line B11, B12, and B22 channel.

C. Thermal-Hanger Shields: (MSS Type 40) Calcium silicate or Cell Glass Insert, encased in sheet metal shield.

1. Calcium Silicate Insert: Galvanized steel shield with waterproofed calcium silicate insert, asbestos free, k value of 0.38 BTU-in/(hr-ft2-deg F), 100-psi average compressive strength, and temperature range of -20-deg. F. to 220-deg F. Insert and shield shall cover entire 360-degree circumference of pipe.
2. Insert Length: Extend minimum of 1 inch beyond sheet metal shield.
3. Minimum shield length and minimum thickness:

PIPE DIAMETER NPS (Inches)	SHIELD LENGTH (Inches)	SHIELD THICKNESS (Gage)
1/2 to 3	12	18

4	12	16
6 and larger	18	16

2.3 MISCELLANEOUS MATERIALS

A. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. All Threaded Rods: Steel with electroplated zinc, threaded for entire length of rod.

C. Structural Steel: ASTM A 36/ steel plates, shapes, and bars, black and galvanized.

D. Grout: Refer to 15050, "Basic Mechanical Materials and Methods."

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

B. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): Clevis hanger with vertical height adjustment for suspension of non-insulated and insulated stationary pipes, NPS 1/2 and larger. Provide clevis cross bolt brace when used with seismic controls are provided at the support location.

   a. Known acceptable source for non-insulated steel piping: Cooper B-Line B3100.
   b. Known acceptable source for non-insulated copper piping: Cooper B-Line B3100C.
   c. Known acceptable source for insulated piping: Cooper B-Line B3108.

2. Adjustable Pipe Saddle Supports (MSS Type 38): Steel stanchion-type support for pipes, NPS 2-1/2 and larger, with vertical height adjustment, steel pipe base stanchion support, u-bolt pipe connector sized for pipe insulation, and steel floor flange isolated from structure with neoprene pad as specified in Division 15 Section, "Mechanical Vibration and Seismic Controls."

   a. Known acceptable source: Cooper B-Line B3088T with B3089.

C. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 and larger.

    a. Known acceptable source for steel piping: Cooper B-Line B3373.
    b. Known acceptable source for copper piping: Cooper B-Line B3373C.

D. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

    a. Known acceptable source: Cooper B-Line B3202.

2. Steel Clevises (MSS Type 14): For 40 to 250 deg F piping installations.

    a. Known acceptable source for steel piping: Cooper B-Line B3201.

E. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Install mechanical anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturers written instructions.

    a. Known acceptable source for steel piping: Cooper B-Line B3014.

2. Steel Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams. Clamp must attach to both sides of beam to prevent accidental release of clamp when horizontal force is applied.

    a. Known acceptable source for steel piping: Cooper B-Line B3050.

F. Thermal-Hanger Shields: Provide manufactured units as specified in Part.

    a. Spring Hangers and Supports: Refer to Division 15 Section, “Mechanical Vibration and Seismic Controls.”

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping.

E. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," are not exceeded.

J. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   a. Use thermal-hanger shield insert with clamp sized to match OD of insert.
   b. Do not exceed pipe stress limits according to ASME B31.9.

2. Install MSS SP-58, Type 40 Thermal-hanger protective shields with inserts on piping. Provide with vapor barrier on cold piping. Shields shall span arc of 360 degrees.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 15145

SECTION 15170 - MOTORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes basic requirements for motors. It includes motors that are factory-installed as part of equipment and appliances as well as field-installed motors.

1.2 REFERENCE STANDARDS

A. Federal Aviation Association (FAA)

1. C-1217f Electrical Work, Interior.

B. National Electrical Manufacturers Association (NEMA)

1. MG-1 Motors and Generators.
2. MG-10 Energy Management Guide for Selection and Use of Polyphase Motors.

C. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC).

D. Underwriting Laboratories (UL)

1. 1004 UL Standard for Safety Electric Motors.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70, "National Electrical Code."

B. NRTL Listing: Provide NRTL listed motors.

1. Term "Listed": As defined in "National Electrical Code," Article 100.
2. Listing Agency Qualifications: "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

C. Comply with NEMA MG-1, "Motors and Generators."

D. Comply with NEMA MG-10, “Energy Management Guide for Selections and Use of Polyphase Motors”.

E. Comply with UL 1004, "Motors, Electric."

F. Comply with FAA-C-1217f.

1.4 SUBMITTALS

A. Submit sets of bound Motor Instruction Books. Include Operation and Maintenance Manual, renewal parts catalogue, and outline drawing for each different type and size motor.

B. Submit product data for each motor as follows:

1. Rated voltage;
2. Number of phases;
3. Frequency in hertz;
4. Amperes of full load and no load;
5. Nominal speed at full load;
6. Winding insulation class;
7. NEMA design;
8. Temperature rise at full load and service factor (reference NEMA MG-1, Part 12);
9. Bearing type;
10. Motor dimensions and frame number;
11. NEMA machine type classification;
12. Efficiency and power factor at 1/2, 3/4, and full load;
13. Service factor;
14. Motor horsepower;
15. Ambient temperature rating;
16. Frame size;
17. RPM; and
18. Locked kVA code.

PART 2 - PRODUCTS

2.1 MOTORS, GENERAL

A. General: Requirements below apply to motors covered by this Section except as otherwise indicated. Each single speed, full voltage starting motors 5 horsepower and greater shall have a full load power factor of 0.85 minimum. Motors with less than 0.85 shall be corrected to 0.90 using factory installed corrective devices on the motors unless the motor is powered directly by a variable frequency drive with a minimum displacement power factor of 0.95 at all speeds and loads.

B. Motors 1/2 HP and Larger: 460 V, Three-Phase, unless otherwise noted.

C. Motors Smaller Than 1/2 HP: 115 V, Single-Phase, unless otherwise noted.

D. Frequency Rating: 60 Hz.

E. Motors shall have full nameplate horsepower available with the indicated service factor at sea level.

F. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100 percent of rated capacity.

G. Temperature Rise: Based on 40 deg C ambient except as otherwise indicated. The temperature rise shall not exceed 80 deg. C at 1.0 service factor or 90 deg. C at 1.15 service factor.

H. Enclosure: Totally enclosed, fan cooled (TEFC).

I. Provide coupling device required between the motor and the driven equipment.

J. Provide each motor with stainless steel nameplates in accordance with NEMA MG-1, Section 10.37 and NEC, Section 430-7. Attach nameplate with stainless steel fastening screws.

K. Provide each motor with a diagonally split, cast iron conduit box amply dimensioned for the motor lead terminations, including a grounding lug. Supply a gasket designed for the enclosed type and motor location.

L. Minimum Insulation Class: F

M. Known Acceptable Source: Teco American Inc., Model: Max - E2, 1 HP and larger.
Teco American Inc., Model: Max-E1, 3/4 HP.
GE Motors and Industrial Systems: Energy Saver™; 1/2 HP and smaller.

N. Paint: Manufacturer's standard shop paint for prime and finish coats is acceptable.

O. Factory certified efficiency at full load: In accordance with IEEE 112 test procedures, Method B: Premium efficiency for 3/4 HP and larger; High Efficiency for 1/2 HP and smaller.

2.2 POLYPHASE MOTORS

A. General: Squirrel-cage induction-type conforming to the following requirements, except as otherwise indicated, with normal starting torque and low starting current.

B. NEMA Design Letter Designation: "B." Test in accordance with NEMA MG-1.

C. Multi-Speed Motors: Separate winding for each speed.

D. Motor insulation shall sustain temperature rises according to NEMA MG-1 Section 12.42 and withstand voltage spikes and voltage rise times according to NEMA MG-1 Section IV, Part 31.40.4.2.

E. Internal Thermal Overload Protection For Motors: For motors so indicated, protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.

F. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading of the application. Provide Type L copper tubing extension lines to grease fittings.

G. Variable Speed Motors for Use With Solid-State Variable Frequency Drives: Energy efficient units with ratings, characteristics, and features which comply with NEMA MG-1 Section IV, Part 31. The units must have the written approval of the variable frequency drive manufacturer.

2.3 SINGLE-PHASE MOTORS

A. General: Single phase motors shall be capacitor start type, except that motors rated 1/6 hp and less may be split-phase type.

B. NEMA Design Letter Designation: N .

C. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens the power supply circuit to the motor, or a control circuit arranged for external connection. Protection operates when winding temperature exceeds a safe value calibrated to the temperature rating of the motor insulation. Provide device that automatically resets when motor temperature returns to normal range except as otherwise indicated.

D. Bearings, belt connected motors and other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, prelubricated sleeve bearings may be used for other single phase motors.

E. Motor insulation shall sustain temperature rises according to NEMA MG-1, Section 12.41.

F. Minimum Service Factor for 1/3 HP and smaller shall be 1.35.

G. Minimum Service Factor for 1/2 HP and smaller shall be 1.25.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: The following requirements apply to field-installed motors.

B. Install motors in accordance with manufacturer's published instructions and the following:

1. Direct Connected Motors: Mount securely in accurate alignment.
2. Belt Drive Motors: Use adjustable motor mounting bases. Align pulleys and install belts. Use belts identified by the manufacturer and tension belts in accordance with manufacturer recommendations.
3. In accordance with FAA Specification C-1217f.

3.2 COMMISSIONING

A. Check operating motors, both factory and field-installed, for unusual conditions during normal operation. Coordinate with the commissioning of the equipment for which the motor is a part.

B. Report unusual conditions.

C. Correct deficiencies.

3.3 IDENTIFICATION

A. Provide motor identification as per requirements of Section 15190.

END OF SECTION 15170

SECTION 15171 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes variable frequency drives for the following:

1. Variable air volume supply fans.

1.2 REFERENCE STANDARDS

A. The current issues of the following documents, in effect on the date of the invitation for bid, form a part of this specification and are applicable to the extent specified herein.

1. Electronic Industries Association (EIA/TIA)

   a. TIA-232 Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Exchange.
   b. TIA-485 Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
   c. TIA-568A Commercial Building Telecommunications Wiring Standard.

2. Institute for Electrical and Electronics Engineers (IEEE)

   a. 519-1992 Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

3. International Standards Organization (ISO)

   a. ISO-9000 Quality Management and Quality Assurance Standards.

4. National Electrical Manufacturer Association (NEMA)

   a. ICS 2 Standard for Industrial Control Devices, Controllers and Assemblies.
   b. 250 Enclosures for Electrical Equipment (1000 Volts Maximum).

5. National Fire Protection Association (NFPA)

   a. 70 National Electrical Code (NEC).

6. National Institute of Standards and Technology (NIST)

7. Occupational Safety and Health Administration (OSHA)

a. 29 CFR 1910.7 Definitions and requirements for a nationally recognized testing laboratory

8. Underwriters Laboratories (UL)

a. 508 Electrical Industrial Control Equipment.

1.3 DESCRIPTION OF WORK:

A. Furnish for installation by Division 16 Variable Frequency Drives (VFD) for supply fans as designated on the drawings and in the sequence of operations as variable speed.

B. Each VFD shall interface with the Direct Digital Control Panel (DDCP) as specified in section 15975, “Control Systems - Electronic and Direct Digital Controls”.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide variable frequency drive motor controllers from manufacturers regularly engaged in the manufacture of equipment of the types and capacities indicated, with such products in satisfactory use in similar service for not less than 5 years. Manufacturer must also maintain, within 100 miles of the project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Material furnished under this Division shall be standard cataloged products of recognized manufacturers regularly engaged in the production of such material and shall be the latest design.

C. Components and Installation: NFPA 70 "National Electrical Code."

D. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

E. NEMA Compliance: NEMA ICS 2, "Industrial Control Devices, Controllers and Assemblies."

F. UL Compliance: UL 508, "Electric Industrial Control Equipment."

G. Single-Source Responsibility: Obtain variable frequency drives from a single manufacturer.

H. Materials shall be the best of their respective kinds. Materials shall be new. Items necessary for the completion of the work and the successful operation of a product shall be provided even though not fully specified or indicated in each section. ISO-9000 registration is an acceptable method of demonstrating compliance with industry quality standards.

I. Upon completion of the installation, a VFD factory certified service technician shall verify by test and written report, that each VFD is fully functional, installed in accordance with the plans

and specifications, and calibrated within the operational limits specified. Acceptable documentation and test procedures, shall be as approved on the initial project submittals.

1.5 COORDINATION

A. Controls: Coordinate features of variable frequency drives and control devices with pilot devices, control circuits, and DDCP interfaces as required in Section 15975 "Control Systems - Electronic and Direct Digital Controls".

B. Coordinate with Section 15854 "Central-Station Air-Handling Units" for requirements of the variable speed supply fans. Obtain minimum speed and resonant frequencies of air handling units and program minimum frequency and resonant frequency lockouts to avoid these frequencies.

C. Coordinate with Section 15170 "Motors" for requirements of the variable speed supply fan motors. Ensure that VFDs are compatible with the motors provided.

D. Coordinate with Division 16 for mounting, installation and wiring of VFDs.

1.6 EXTRA MATERIALS

A. Furnish extra materials as described below and in Division 1, that match products installed, are packaged with protective covering for storage, and are identified with labels clearly describing contents. Furnish the quantity indicated, or when a percentage is indicated, a quantity equal to the percentage listed of the number of units installed under this contract, but not less than one. Turn over extra materials to the COR prior to the start of the final acceptance testing.

1. Spare Fuses: Furnish five spare fuses for each type and size used in single phase/control circuits. Furnish two spare sets of three fuses for each type and size used in three phase power circuits.

2. Spare Air Filters: For VFDs which include ventilation fans and air filters, furnish one set of spare air filters for each drive provided.

1.7 SUBMITTALS

A. Submit product data for VFDs including but not limited to product specifications, wiring diagrams, installation instructions, start-up instructions, and operation and maintenance instructions.

B. Provide complete DDCP system interface documentation which clearly demonstrates how the VFDs will interface with the DDCP.

C. Provide complete shop drawings, schematics, software and hardware listing, and such other data necessary to fully describe and substantiate compliance with these specifications. On site work shall not begin until submittals have been approved by the COR.

D. ISO-9000 Registration: Provide proof of ISO-9000 registration for each manufacturer of ISO-9000 registered equipment.

E. UL Listing: Provide proof of UL listing for each VFD component.

F. Provide computer generated harmonics distortion report which predicts the cumulative Total Harmonic Voltage (THD) and Total Harmonic Current (TDD) generated by the VFDs provided. The computer program shall be provided and supported by the Manufacturer of the VFDs. A VFD manufacturer approved technician shall input electrical system information into the program, including but not limited to transformer KVA and impedance, generator KVA and impedance, short circuit capability, facility loads, cable/wire impedance, VFD configuration, and other information required by the program. The program report shall include a summary of all the input data, as well as a summary of the 1st through 31st harmonics with frequency, percent voltage distortion, percent current distortion, and harmonic current amps for each harmonic. The report shall clearly show that the expected cumulative THD and TDD with all drives operating is less than the limits set in this specification.

G. Startup personnel qualifications: Submit resume listing startup personnel qualifications including manufacturer's certification as an approved system technician and a list of recently completed projects demonstrating 5 years of system startup experience.

1.8 PLACING SYSTEMS INTO OPERATION

A. Provide start-up commissioning of the VFD by a factory certified service technician. The commissioning personnel shall be the same personnel that provide the factory service and warranty repairs at the Owner's site. This service shall include, but not be limited to, the following:

1. Verification of wire terminations.
2. Installation verification of proper operation of the VFD, motor, and DDCP interface.
3. Verification of motor voltage and frequency, proper control input, and setpoint adjustment of minimum speed, maximum speed, acceleration and deceleration rates, and resonant frequency lockouts.
4. Measure voltages at the output of the drive and at the motor leads to verify that the controller is providing voltage which does not exceed the maximum voltage allowed by NEMA 31.40.4.2.

B. Provide laminated VFD operating instructions and safety procedures and attach to door of VFD.

1.9 OPERATION AND MAINTENANCE DATA

A. Provide six (6) copies of Operation and Maintenance manuals. Manuals shall include required maintenance and troubleshooting procedures for each VFD provided, a list of recommended spare parts for each drive, and complete wiring and interface diagrams. Operating instructions shall include VFD operation, contractor bypass operation, dual motor selection instructions, and safety procedures.

B. Manuals shall document complete commissioning data which includes final VFD settings, parameters, and configuration data.

C. Manuals shall include complete operating, programming, maintenance and troubleshooting procedures for the DDCP interface.

1.10 GUARANTEE OF WORK

A. The VFD shall be warranted by the manufacturer for a period of 36 months from the date of shipment. The warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer to provide factory authorized on-site service.

1.11 TRAINING

A. Provide 3 eight hour training sessions. Course must include safety requirements, basic drive theory, circuit description, operation principles, DDCP interface requirements, installation, maintenance, and troubleshooting. Course shall be provided for three persons in each session. Instructors must be certified by the manufacturer. Equipment installers are not acceptable instructors.

PART 2 - PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Danfoss Graham Co.
2. ABB Industrial Systems

2.2 HARDWARE REQUIREMENTS

A. General: Provide controllers listed and labeled as a complete unit and arranged to provide variable speed of a standard NEMA Design B, 3-phase, induction motor by adjusting output voltage and frequency of controller. The motor current shall closely approximate a sine wave. Controller shall be designed and rated by the manufacturer for the type of load (e.g., fans) with which it is used. Controller shall also be approved by the manufacturer for the type of connection used between the motor and load (direct connection or power transmission connection).

B. Enclosure: The VFD and all options shall be housed in a NEMA 1 enclosure which carries the UL 508 listing label from a UL certified panel shop.

C. Isolation Transformer: When required to comply with other sections of this specification, provide 1-to-1 ratio isolation transformer, with capacity coordinated by the manufacturer for the controller, motor, drive, and load combination. Provide additional ventilation/cooling as required to safely operate the isolation transformer.

D. Ratings: As follows:

1. Output Rating: 3-phase, 0 to 120 Hz, with voltage proportional to frequency throughout the voltage range to maintain desired motor magnetization current suitable for fan control.
2. Torque Output: Variable as required for control of fans.
3. Starting Torque: 100 percent of rated torque, or as indicated.
4. Speed Regulation: Plus or minus 1 percent.
5. Efficiency: 95 percent minimum at full load, 60 Hz.
6. Power Factor: 0.95 throughout the speed and load range.

E. Isolated control interface to allow the controller to follow one of the following over an 11:1 speed range:

1. Electrical Signal: 4 to 20 milli-amperes at 24 V.
2. Electrical Signal: 0 to 10 VDC.

F. Internal Adjustability: Provide the following internal adjustment capabilities:

1. Minimum Speed: 5 to 25 percent of maximum RPM.
2. Maximum Speed: 80 to 100 percent of maximum RPM.
3. Acceleration: 2 to 300 seconds.
4. Deceleration: 2 to 300 seconds.
5. Current Limit: 50 to 110 percent of maximum rating.

G. Self-protection and reliability features shall include:

1. Electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications. Drive shall include semi-conductor rated input fuses to protect power components.
2. Snubber networks to protect against malfunction due to electrical system voltage transients.
3. Motor Overload Relay: Adjustable and capable of NEMA class 10 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. The VFD interrupting rating shall be minimum 100,000 amps.
6. Instantaneous Overcurrent Trip.
7. Loss of Phase Protection. Control power shall be maintained for a minimum 5 seconds during a loss of power/phase to prevent nuisance tripping.
8. Reverse Phase Protection.
9. Under- and Over-Voltage Trips.
10. Drive Over-temperature Trip.
11. Motor Over-temperature Trip.
12. Short Circuit Protection.
13. Ground Fault Protection.

H. Motor Protection: To prevent breakdown of motor winding insulation and to prevent damage to the motor windings and the motor bearings due to circulating currents, limit the rate of output

voltage rise over time (dV/dt) to a maximum of 1500 V/msec at the motor. Utilize one or both of the following methods:

1. The VFD shall allow the switching frequency to come down to a preset value, which is reached at a predetermined high speed output frequency.
2. Provide output line reactors and voltage clamp module consisting of a three phase, full wave diode bridge rectifier and dissipating resistors, to reduce motor operating temperature, RFI, and EMI. Filters using only inductors, capacitors and or resistors cannot provide precise clamping of output voltage and are not acceptable.

I. Automatic Reset/Restart: Attempt 3 restarts after controller fault or on return of power to the system following an interruption and before shutting down for manual reset or fault correction. Provide for restarting during deceleration without damage to the controller, motor, or load.

J. Power Interruption Protection: Prevent motor re-energizing after a power interruption until motor has stopped.

K. Power line noise generated by the VFDs shall be individually and cumulatively limited to a voltage distortion factor and line notch depth as defined in IEEE Standard 519-1992, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems. The total voltage distortion shall not exceed 3%. The total current distortion shall not exceed 5%. Ensure that line notching and zero crossings are kept within allowable levels on both utility power and on generator power. Provide line reactors, isolation transformers, filters, and chokes as required.

L. Motor noise as a result of the VFD shall be limited to three dB over across the line operation, measured at three feet from the motor's center line.

M. The VFDs full load amp rating shall meet or exceed the requirements of the motor. The VFD shall have a 110% overload current rating for 60 seconds and 220% overload current rating for 1 second while starting.

N. The VFD shall have minimum of four programmable resonant frequency lockouts with adjustable frequency bandwidths. These lockouts shall be adjusted to match the requirements of the fan controlled by the VFD.

O. The VFD shall be able to start into a rotating load in either direction without damage or degradation to the VFD or motor.

P. The drive shall be immune to input or output switching. Input or output power may be disconnected while the drive is operating. VFDs without this feature must be interlocked to stop the drive when an input or output disconnect switch is operated as recommended by the manufacturer to prevent damage to the drive.

Q. Control and Indicating Features

1. Door mounted Hand/Off/Auto switch to start and stop the VFD. In the AUTO position, the VFD shall start/stop from a remote contact closure from the DDCP. In the HAND position, the VFD shall run regardless of the remote contact position.
2. Local/Remote selector switch. In the remote position, motor speed is determined by signal from the DDCP. In the local position, the motor speed is determined by the manual speed control.
3. Lost DDCP signal reference speed: When speed control signal from DDCP drops below 50 percent of the minimum signal, the VFD shall switch to default speed control after a selectable time delay. Default speed control shall be user selectable to: go to minimum speed, go to maximum speed, go to a preset speed, or to stop. Unless indicated otherwise, each drive shall be initially set to go to a preset speed of 50%.
4. The VFD shall include one set of auxiliary contacts which are closed when the drive is in the contractor bypass mode.
5. The VFD shall include door mounted indication for the following: Power on, Drive Ready, Run, Hand/Off/Auto, Local/Remote.
6. The VFD shall include door mounted indication for the following fault conditions: Under-voltage, High Line, Phase Loss, Bus Over-voltage, Over-current, Ground Fault, Overload, Over-temperature, External Fault, Ground Fault.

R. DDCP Interface requirements

1. The VFD shall include a TIA-232, or TIA-485, digital communications interface which provides the capability for future bi-directional communication between the VFD and the DDCP. The interface shall utilize an industry standard protocol or a fully open published protocol. No proprietary protocol will be allowed.
2. The VFD shall accept a 0-10 VDC or 4-20 mA input speed control signal from the DDCP.
3. The VFD shall accept a dry contact input for remote start/stop.
4. The VFD shall accept a dry contact input for remote safety interlock. Opening this dry contact shall cause the drive to stop in both the drive and bypass modes. The drive shall not restart until manually reset.
5. The VFD shall include dry contact outputs for drive run status and drive fault status.

S. Adjustments

1. Speed, 0%-100%.
2. Acceleration Time, 2-300 seconds.
3. Deceleration Time, 2-300 seconds, with override circuit to prevent nuisance trips if deceleration time is set too short.
4. Current Limits, 0-115%.
5. Overload trip setpoint.
6. Offset and gain to condition the input speed signal.
7. Preset speed, activated on contact closure.

T. Service Conditions

1. Ambient Temperature, 32-104 degrees F.
2. Relative Humidity, 0-95% Non Condensing.
3. AC Line Voltage variation, plus or minus 10 percent of nominal.

4. Input Frequency Rating: 60 Hz, plus or minus 2 Hz.

U. Special Features

1. Manual contractor bypass shall provide all circuitry necessary to transfer the motor from the VFD to the power line, or from the line to the controller. The bypass circuitry shall be mounted in a separate section of the VFD enclosure. Motor overload protection shall be provided in both the drive and bypass modes. The bypass shall totally isolate the drive from both the power line input and the motor.
2. A door interlocked, pad lockable drive disconnect switch shall be provided to disconnect power from the VFD only.
3. A second fused disconnect switch or circuit breaker shall be provided as a means of disconnecting all power to both the VFD and bypass circuits, as well as providing short circuit and locked rotor protection to the motor while in the bypass mode.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with manufacturer's written installation instructions, Division 16 requirements, and NEC. Coordinate installation under Division 16. Protect components from dust and construction debris.

B. Every raceway entry into a control panel shall be provided with a bushing in accordance with Division 16 requirements.

C. Do not energize the VFDs until the factory trained service representative has performed the initial startup inspection and has verified that the drives can be energized. Follow startup procedures specified under "Placing Systems Into Operation".

END OF SECTION 15171

SECTION 15180 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for hot-water heating, chilled-water cooling, and condensate drain piping.

B. Grooved-type piping and fittings shall not be permitted for HVAC piping.

1.2 SUBMITTALS

A. Prepare submittal in accordance with procedures of Division 1 Section, “Submittals.”

B. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

C. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

D. Welding Certificates: Copies of certificates for welding procedures and personnel.

E. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.
4. Chemical Treatment Reports: Before start of Work and after work is completed.

F. Prepare and distribute operations and maintenance data as specified in Division 1 Section, “Operation and Maintenance Manual Data.”

1.3 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.4 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate piping installation with equipment supports.

C. Coordinate pipe fitting pressure classes with products specified in related Sections.

D. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base.

E. Coordinate installation of pipe sleeves for penetrations through walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Fire Stopping" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53, Type E (electric-resistance welded), Grade A, Schedule 40, black steel, plain ends.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

C. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

D. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

E. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

F. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

G. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures. Refer to section 15050 “Basic Mechanical Materials and Methods”.

2.4 VALVES

A. Valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

2.5 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.

C. Y-Pattern Strainers 1/2-inch to 2-inch: Cast-iron body (ASTM A48, Class 30), rated for 400 psi at 150 degrees F; End connections, ANSI B1.20.1 250 pound screwed, Screen, 304 stainless steel with 0.045-inch perforations and with free screen area minimum of three times the area of the strainer inlet pipe; Cover, threaded; and bottom drain connection. Known Acceptable Source: Armstrong Y-Type Model A1SC. Fan-coil units shall have factory installed strainers.

D. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

E. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

F. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot and Chilled Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing, ASTM B 88, with soldered joints.

B. Hot and Chilled Water, NPS 2-1/2 inches and Larger: Schedule 40 black steel pipe, ASTM A53, with welded and flanged joints.

C. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Ball valves.
2. Throttling Duty: Globe and ball valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

3.3 PIPING INSTALLATIONS

A. Refer to Division 15 Section, "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Seismic Protection is specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping.
2. Support multiple runs of horizontal piping on trapeze hanger with pipe clamps.
3. Spring hangers to support vertical runs.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 12 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 12 feet; minimum rod size, 5/8 inch.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Section 15050 "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Automatic vent valves: Install automatic vent valves at the top of each hydronic riser, at high points of chilled and heating hot water piping, at all locations where air pockets are likely to

form, and as indicated on the Drawings. Install in accordance with the manufacturers instructions, and the following:

1. Install shut off valve between riser and vent.
2. Pipe vent outlet to plumbing drain or as indicated.

B. Manual Vent Valve: Install manual vent valve in accordance with the manufacturers instructions, and the following:

1. Install manual vent valves at top of each hydronic terminal at highest point; and
2. Install manual vent valves on each hydronic piping drop in direction of flow for mains, branches, and runouts.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with ball valve around control valve.

D. Install ports for pressure and temperature gages at coil inlet connections.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, un-insulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. 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.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure or 100 psig, whichever is greater. 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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least four hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

3.9 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Lubricate motors and bearings.

3.10 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 15180

SECTION 15185 - HYDRONIC PUMPS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the following categories of hydronic pumps for hydronic systems:
   1. In-line circulators.

B. Related Sections include the following:
   1. Division 15 Section "Mechanical Vibration and Seismic Controls" for inertia pads, isolation pads, spring supports, and spring hangers.

1.2 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities; shipping, installed, and operating weights; furnished specialties; final impeller dimensions; and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include Setting Drawings with templates for installing foundation and anchor bolts and other anchorages.
   1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For pumps to include in maintenance manuals specified in Division 1.

1.3 QUALITY ASSURANCE

A. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction requirements.

B. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

D. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.5 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. Mechanical Seals: One mechanical seal for each pump.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. In-Line Circulators:
      a) Bell & Gossett ITT; Div. of ITT Fluid Technology Corp.
      b) Taco; Fabricated Products Div.

2.2 GENERAL PUMP REQUIREMENTS

A. Pump Units: Factory assembled and tested.

B. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be non-overloading over full range of pump performance curve.

C. Motors Indicated to Be Energy Efficient: Minimum efficiency as indicated according to IEEE 112, Test Method B. Include motors with higher efficiency than "average standard industry motors" according to IEEE 112, Test Method B, if efficiency is not indicated.

2.3 IN-LINE CIRCULATORS

A. Description: Horizontal, in-line, centrifugal, single-stage, bronze-fitted, radially split case design; rated for 125-psig minimum working pressure and a continuous water temperature of 225 deg F.
   1. Casing: Cast iron, with threaded companion flanges for piping connections, and threaded gage tappings at inlet and outlet connections.

a) Connection Option: Unions at connections for casings that are not available with threaded companion flanges.

2. Impeller: ASTM B 36/B 36M, rolled-temper-brass fabrication, statically and dynamically balanced, closed, overhung, single suction, and keyed to shaft.
3. Shaft and Sleeve: Steel shaft with oil-lubricated copper sleeve.
4. Seals: Mechanical type. Include carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
5. Pump Bearings: Oil-lubricated, bronze journal and thrust type.
6. Motor Bearings: Oil-lubricated, sleeve type.
7. Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
8. Motor: Resiliently mounted to pump casing.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation.
   1. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Install pumps according to manufacturer's written instructions.

B. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Suspend in-line pumps using continuous-thread hanger rod and vibration-isolation hangers. Install seismic bracing as required by authorities having jurisdiction.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pump to allow service and maintenance.

C. Connect piping to pumps. Install valves that are the same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check valve and throttling valve on discharge side of in-line circulators.

F. Install pressure gages on pump suction and discharge. Install at integral pressure-gage tappings where provided.

G. Install electrical connections for power, controls, and devices.

H. Electrical power and control wiring and connections are specified in Division 16 Sections.

I. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 COMMISSIONING

A. Verify that pumps are installed and connected according to the Contract Documents.

B. Verify that electrical wiring installation complies with manufacturer's written instructions and the Contract Documents.

C. Perform the following preventive maintenance operations and checks before starting:
   1. Lubricate bearings.
   2. Remove grease-lubricated bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's written instructions.
   3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.
   4. Verify that pumps are free to rotate by hand and that pumps for handling hot liquids are free to rotate with pumps hot and cold. Do not operate pumps if they are bound or drag, until cause of trouble is determined and corrected.
   5. Check suction piping connections for tightness to avoid drawing air into pumps.
   6. Clean strainers.
   7. Verify that pump controls are correct for required application.

D. Starting procedure for pumps with shutoff power not exceeding safe motor power is as follows:
   1. Prime pumps by opening suction valves and closing drains, and prepare pumps for operation.
   2. Start motors.
   3. Open discharge valves slowly.
   4. Check general mechanical operation of pumps and motors.

E. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except open discharge valves before starting motors.

END OF SECTION 15185

SECTION 15190 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes mechanical identification materials and devices.

1.2 REFERENCE STANDARDS

A. FAA ORDER 1365.1

B. American Society of Mechanical Engineers (ASME)

1. A13.1 Scheme for Identification of Piping Systems.

C. American Society for Testing and Materials (ASTM)

1. C1036 Standard Specification for Flat Glass.
2. D709 Standard Specification for Laminated Thermosetting Material.

1.3 SUBMITTALS

A. Product data for identification materials and devices.

B. Samples of color, lettering style, and other graphic representation required for each identification material and device.

C. Valve Schedules: Submit valve schedules for each piping system. Reproduce on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification. Mark valves intended for emergency shutoff and similar special uses. Furnish extra copies (in addition to mounted copies) for Maintenance Manuals.

1.4 QUALITY ASSURANCE

A. Comply with ASME A13.1 and FAA Order 1365.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate installation of identifying devices after completion of covering and painting where devices are applied to surfaces. Install identifying devices prior to installation of acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 IDENTIFYING DEVICES AND LABELS

A. General: Products specified are manufacturer's standard products of categories and types required for each application as referenced in Division 15 Section 15050 "Basic Mechanical Materials and Methods". Where more than single type is specified for listed application, selection is Installer's option, but provide single selection for each product category.

B. Equipment Nameplates: Metal nameplate permanently fastened to equipment and having data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: An accessible and visible location.

C. Snap-On Plastic Pipe Markers: Manufacturer's standard pre-printed, semi-rigid Snap-On, color-coded pipe markers conforming to ASME A13.1.

D. Lettering: Use piping system terms as indicated and abbreviate only as necessary for each application length.

1. Arrows: Either integrally with piping system service lettering (to accommodate both directions), or as separate unit, on each pipe marker to indicate direction of flow.

E. Plastic Duct Markers: Manufacturer's standard laminated plastic, duct markers in the following color code:

1. Green: Cold air.
2. Yellow: Hot air.
3. Yellow/Green: Supply air.
4. Blue: Exhaust, outside, return, and mixed air.
5. Terminology: Include direction of air flow, duct service (supply, return, and exhaust), duct origin (from), duct destination (to), and design air flow.

F. Plastic Tape: Manufacturer's standard color-coded, pressure- sensitive, self-adhesive, vinyl tape, at least 3 mils thick.

1. Width: 1-1/2 inches wide on pipes with outside diameters (including insulation) less than 6 inches; 2-1/2 inches wide for larger pipes.
2. Color: Comply with ASME A13.1, except where another color selection is indicated.

G. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Provide a 5/32-inch hole for fastener.

1. Material: 19-gage polished brass.
2. Size: 1-1/2-inch diameter, except as otherwise indicated.
3. Shape: Round.

H. Valve Tag Fasteners: Brass chain (wire link or beaded type) or brass S-hooks.

I. Access Panel Markers: 1/16-inch-thick engraved plastic-laminate markers, with abbreviated terms and numbers corresponding to concealed valve. Provide 1/8-inch center hole for attachment.

J. Valve Schedule Frames: Glazed display frame, with screws for removable mounting on frame, mount as directed by the COR for each page of valve schedule.

1. Frame: Extruded aluminum.
2. Glazing: ASTM C1036, 1/4 inch, single thickness, sheet glass.

   a. Type: Type I, flat transparent.
   b. Class: Class 1, clear.
   c. Quality: Glazing B, for general applications.

K. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Engraved with engraver's standard letter style, of sizes and with terms to match equipment identification.
2. Fasteners: Self-tapping stainless steel screws or contact-type permanent adhesive.
3. Thickness: 1/8 inch, typically.

L. Plastic Equipment Markers: Laminated-plastic, in the following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.
4. Brown: Energy reclamation equipment and components.
5. Blue: Equipment and components that do not meet any of above criteria.
6. Terminology: Include following, matching schedules as closely as possible:

   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions, and rpm.

7. Size: Approximate 2 - 1/2 by 4 inches for control devices, dampers, and valves; and 4 - 1/2 by 6 inches for equipment.

M. Plasticized Tags: Pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 3 - 1/4 by 5 - 5/8 inches.
2. Fasteners: Brass grommets and wire.
3. Nomenclature: Large-size primary wording such as “DANGER,” “CAUTION,” or “DO NOT OPERATE.”

N. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of mechanical systems and equipment.

1. Multiple Systems: Where multiple systems of same name are indicated, identify individual system number as well as service (such as Boiler No. 3, Air Supply No. 1H, or Standpipe F12.)

PART 3 - EXECUTION

3.1 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Plastic markers, with application systems. Install on pipe insulation segment where required for hot non-insulated pipes.

a. Fasten markers on pipes smaller than 6 inches by one of following methods:

1) Snap-On application of pre-tensioned semi-rigid plastic pipe marker.
2) Adhesive lap joint in pipe marker overlap.
3) Laminated or bonded application of pipe marker to pipe (or insulation).
4) Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 inch wide, lapped 1-1/2 inches minimum at both ends of pipe marker, and covering full circumference of pipe.

2. Locate pipe markers and color bands as follows wherever piping is exposed in finished spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

a. Near each valve and control device.
b. Near each branch connection, excluding short take-off for fixtures and terminal units. Mark each pipe at branch, where flow pattern is not obvious.
c. Near penetrations through walls, floors, ceilings, or enter non-accessible enclosures.
d. At access doors, manholes, and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.
f. Spaced at a maximum interval of 50 feet along each run. Reduce intervals to 25 feet in congested areas of piping and equipment.
g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

B. Valve Tags: Install valve tag on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, plumbing fixture supply stops, faucets, convenience and lawn-watering hose bibbs, and similar roughing-in connections of end-use fixtures and units. List tagged valves in valve schedule.

1. Install mounted valve schedule in each major equipment room.

C. Equipment: Install engraved plastic laminate signs or equipment markers on or near each major item of mechanical equipment. Provide signs for following general categories of equipment:

1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Meters, gages, thermometers, and similar units.
3. Fans, blowers, primary balancing dampers, and mixing boxes.
4. Packaged HVAC central-station and zone-type units.
5. Strainers, filters, humidifiers, water treatment systems, and similar equipment.

D. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; or provide stenciled signs and arrows showing duct system service and direction of flow.

1. Location: In each space where ducts are exposed or concealed by removable ceiling system. Locate signs near points where ducts enter into concealed space and at maximum intervals of 50 feet.

3.2 ADJUSTING AND CLEANING

A. Relocate mechanical identification materials and devices which have become visually blocked by work of this Division or other Divisions.

B. Clean face of identification devices, and glass frames of valve charts.

END OF SECTION 15190

SECTION 15250 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe, duct, and equipment insulation.

1.2 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1.	C196	Standard Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
2.	C411	Hot Surface Performance of High Temperature Thermal Insulation.
3.	C447	Estimating the Maximum Use Temperature of Thermal Insulations.
4.	C449	Standard Specification for Mineral Fiber Hydraulic Setting Thermal Insulating and Finishing Cement.
5.	C534	Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
6.	C547	Standard Specification for Mineral Fiber Pipe Insulation.
7.	C552	Standard Specification for Cellular Glass Thermal Insulation.
8.	C553	Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
9.	C612	Mineral Fiber Block and Board Thermal Insulation.
10.	C921	Standard Specification for Determining the Properties of Jacketing Materials for Thermal Insulation.
11.	C1071	Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Materials).
12.	C1136	Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
13.	E84	Standard Test Method for Surface Burning Characteristics of Building Materials.

B. Adhesive and Sealing Council (ASC)

1.	A-7001	Standards for Adhesives for Duct Liner.

C. Federal Specifications (FS)

1.	HH-I-558B	Insulation, Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type).

D. National Fire Protection Association (NFPA)

1.	255	Surface Burning Characteristics of Building Materials.

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

1. Duct Liner Standards.

F. Underwriters Laboratories Inc. (UL)

1. 723 Surface Burning Characteristics of Building Materials.

1.3 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 deg F or higher.

B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

C. Cold Surfaces: Normal operating temperatures less than 75 deg F.

D. Thermal resistivity is designated by an r-value that represents the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogenous material exactly 1 inch thick. Thermal resistivity (r-value) is expressed by the temperature difference in degrees Fahrenheit between the two exposed faces required to cause 1 BTU per hour to flow through 1 square foot at mean temperatures indicated.

E. Thermal Conductivity (k-value): Measure of heat flow through a material at a given temperature difference; conductivity is expressed in units of Btu x inch/h x sq. ft. x deg F.

F. Density: Expressed in pcf.

1.4 SUBMITTALS

A. Product data for each type of mechanical insulation identifying k-value, thickness, and accessories.

B. Samples of each type of insulation and jacket. Identify each sample describing product and intended use. Submit the following sizes of sample materials:

1. Board and Block Insulation: 12 inches square section.
2. Pre-Formed Pipe Insulation: 12 inches long, 2-inch NPS.

C. Material certificates, signed by the manufacturer, certifying that materials comply with specified requirements where laboratory test reports cannot be obtained.

D. Material test reports prepared by a qualified independent testing laboratory. Certify insulation meets specified requirements.

1.5 QUALITY ASSURANCE

A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.

1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.

1.6 SEQUENCING AND SCHEDULING

A. Schedule insulation application after testing of piping and duct systems.

PART 2 - PRODUCTS

2.1 GENERAL

A. Install duct and pipe insulation in accordance with manufacturer's instructions.

B. Duct and pipe insulation shall have a flame spread rating not exceeding 25 and a smoke development rating not exceeding 50 as determined by test procedures specified in ASTM E84, NFPA 255 and UL 723. Ratings shall be determined from tests performed on the composite of insulation, jacket or facing, and adhesive. Adhesives, mastics and cements shall meet the same individual ratings as the minimum requirements.

C. Water-based Adhesives, cements, sealers, mastics, and protective finishes as recommended by the insulation manufacturer for the intended use and as indicated.

D. Staples, bands, wire, wire netting tape corner angles, anchors, and stud pins as recommended by insulation manufacturer for intended use and as indicated.

E. Known Acceptable Source:

1. Glass Fiber:

a. Certain Teed Corporation.

2. Cellular Glass:

a. Pittsburgh Corning Corporation.

3. Flexible Elastomeric:

a. Armstrong World Industries.

b. Halstead Industrial Products.
c. IMOCA.
d. Rubatex Corporation.

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.

B. Jacket: All-purpose, factory-applied, laminated glass-fiber-reinforced, flame-retardant Kraft paper and aluminum foil having self-sealing lap.

C. Board: ASTM C612, Class 2, semi-rigid jacketed board.

1. Thermal Conductivity: 0.26 BTU x (inch/h) x sq. ft. x deg. F average maximum at 75 deg F mean temperature.
2. Density: 12 pcf average maximum.

D. Blanket: ASTM C553, Type II, Class F-1, jacketed flexible blankets.

1. Thermal Conductivity: 0.32 Btu x inch/h x sq. ft. x deg F average maximum, at 75 deg F mean temperature.
2. Density: 4.5 pcf average maximum.

E. Preformed Pipe Insulation: ASTM C547, Class 1, rigid pipe insulation, jacketed.

1. Thermal Conductivity: 0.26 BTU x (inch/h) x sq. ft. x deg F average maximum at 75 deg F mean temperature.
2. Density: 10 pcf average maximum.

F. Adhesive: Produced under the UL Classification and Follow-up service.

1. Type: Non-flammable, water-based.
2. Service Temperature Range: Minus 20 to 180 deg F.

2.3 CELLULAR GLASS

A. Material: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

B. Facing: ASTM C921, Type 1, factory-applied, laminated foil, flame-retardant, vinyl facing.

C. Form: The following as indicated:

1. Blocks: ASTM C552, Type I.

2. Boards: ASTM C552, Type IV.
3. Preformed Pipe: ASTM C552, Type II, Class 2 (jacketed).
4. Special Shapes: ASTM C552, Type III, in shapes and thickness as indicated.

D. Thermal Conductivity: 0.38 Btu x inch/h x sq. ft. x deg F average maximum at 75 deg F mean temperature.

E. Minimum Density: 7 pcf.

F. Maximum Density: 9.5 pcf.

2.4 FLEXIBLE ELASTOMERIC CELLULAR

A. Material: Flexible expanded closed-cell structure with smooth skin on both sides.

1. Tubular Materials: ASTM C534, Type I.
2. Sheet Materials: ASTM C534, Type II.

B. Thermal Conductivity: 0.30 Btu x inch/h x sq. ft. x deg F average maximum at 75 deg F.

C. Coating: Water based latex enamel coating recommended by insulation manufacturer.

2.5 INSULATING CEMENTS

A. Mineral Fiber: ASTM C195.

1. Thermal Conductivity: 1.0 Btu x inch/h x sq. ft. x deg F average maximum at 500 deg F mean temperature.
2. Compressive Strength: 10 psi at 5 percent deformation.

B. Mineral Fiber, Hydraulic-Setting Insulating and Finishing Cement: ASTM C449.

1. Thermal Conductivity: 1.2 Btu x inch/h x sq. ft. x deg F average maximum at 400 deg F mean temperature.
2. Compressive Strength: 100 psi at 5 percent deformation.

2.6 ADHESIVES

A. Flexible Elastomeric Cellular Insulation Adhesive: water-based, contact adhesive recommended by insulation manufacturer.

B. Glass Fiber Lagging Adhesive: MIL-A-3316C, non-flammable adhesive in the following Classes and Grades:

1. Class 1, Grade A for bonding glass cloth and tape to unfaced glass fiber insulation, sealing edges of glass fiber insulation, and bonding lagging cloth to unfaced glass fiber insulation.
2. Class 2, Grade A for bonding glass fiber insulation to metal surfaces.
3. Form an adhesive isolating seal between the vapor barrier jacket and bare pipe. Known acceptable source: Benjamin Foster 95-44.

2.7 JACKETS

A. General: ASTM C921, Type 1, except as otherwise indicated.

B. PVC Jacketing: High-impact, ultra-violet-resistant PVC, 30 mils thick, roll stock ready for shop or field cutting and forming to indicated sizes.

1. Provide PVC jacketing in accordance with the requirements indicated. PVC jacketing is not required for return air plenums. Colors will be selected by the COR. Known acceptable source: CEEL-TITE 330.
2. Provide welding adhesive for PVC jacketing on longitudinal and circumferential seams. Known acceptable source: CEEL-TITE No. 300.

C. PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20 mil thick, high-impact, ultra-violet-resistant PVC.

1. Adhesive: As recommended by insulation manufacturer.
2. Finish and Thickness: Painted finish, 0.016 inch thick.
3. Moisture Barrier: 3 mil Dupont Surlyn
4. Elbows: Preformed 45-degree and 90-degree, short- and long-radius elbows, same material, finish, and thickness as jacket.

2.8 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Woven glass fiber fabrics, plain weave, presized a minimum of 8 ounces per sq. yd.

1. Tape Width: 4 inches.
2. Cloth Standard: MIL-C-20079H, Type I.
3. Tape Standard: MIL-C-20079H, Type II.

B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Galvanized Steel: 0.005 inch thick.
2. Aluminum: 0.007 inch thick.

C. Wire: 14 gauge nickel copper alloy, 16 gauge, soft-annealed stainless steel, or 16 gauge, soft-annealed galvanized steel.

D. Corner Angles: 28 gauge, 1 inch by 1 inch aluminum, adhered to 2 inches by 2 inches Kraft paper.

E. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.

2.9 SEALING COMPOUNDS

A. Vapor Barrier Compound: Water-based, fire-resistive composition.

1. Water Vapor Permeance: 0.08 perm maximum.
2. Temperature Range: Minus 20 to 180 deg F.

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.

1. Water Vapor Permeance: 0.02 perm maximum.
2. Temperature Range: Minus 50 to 250 deg F.
3. Color: Aluminum.
4. Known acceptable source: Benjamin Foster 30-80 (finish coat) for use with 8 ounce canvas and Benjamin Foster 30-90 for use with glass cloth.
5. Provide sealant material for all cellular glass joints. Known acceptable source: PITTSEAL 444 Sealant by Pittsburgh Corning Corporation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale, and dirt.

B. Chilled Water Pipe: Drain water from piping before installing insulation, to ensure complete dryness of pipe.

C. Mix insulating cements with clean potable water. Mix insulating cements contacting stainless-steel surfaces with demineralized water.

1. Follow cement manufacturer's printed instructions for mixing and portions.

3.2 INSTALLATION, GENERAL

A. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each mechanical system.

B. Select accessories compatible with materials suitable for the service. Select accessories that do not corrode, soften, or otherwise attack the insulation or jacket in either the wet or dry state.

C. Install vapor barriers on insulated pipes, ducts, and equipment having surface operating temperatures below 60 deg F.

D. Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions.

E. Install insulation with smooth, straight, and even surfaces.

F. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

G. Seal penetrations for hangers, supports, anchors, and other projections in insulation requiring a vapor barrier.

H. Seal Ends: Except for flexible elastomeric insulation, taper ends at 45 degree angle and seal with lagging adhesive. Cut ends of flexible elastomeric cellular insulation square and seal with adhesive.

I. Apply adhesives and coatings at manufacturer's recommended coverage-per-gallon rate.

J. Keep insulation materials dry during application and finishing.

K. Replace insulation damaged by moisture or other means which cannot be repaired satisfactorily, including unit with vapor barrier damage. Insulation that has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also repair any damage caused by condensation. Install insulation in accordance with the manufacturer’s instructions and the following:

1. Insulate valves, fittings, and flanges of chilled water pipes. Refer to individual specification sections for other insulated items.
2. Provide complete moisture and vapor seal wherever insulation terminates against metal hangers.
3. Maintain integrity of vapor barrier on equipment insulation. Protect against puncture.
4. Neatly level edges at interruptions of insulation. Do not extend insulation over nameplate.
5. Install vapor barrier over outer layer and seal all joints.
6. Install contraction joints, as necessary, to prevent vapor barrier and insulation damage.

L. Items Not Insulated: Unless otherwise indicated do not apply insulation to the following systems, materials, and equipment:

1. Fibrous glass ducts.
2. Metal ducts with duct liner.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
5. Flexible connectors for ducts and pipes, except chilled water pipes and valves.
6. Vibration control devices.
7. Testing laboratory labels and stamps.

8. Nameplates and data plates.
9. Access panels and doors in air distribution systems.
10. Fire protection piping systems.
11. Sanitary drainage and vent piping.
12. Drainage piping located in crawl spaces, unless indicated otherwise.
13. Chrome-plated pipes and fittings, except for plumbing fixtures for the disabled.

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints. Bond with adhesive.

B. Stagger joints on both single and double layers of insulation.

C. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.

D. Apply insulation with a minimum number of joints.

E. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Cover circumferential joints with butt strips, at least 3 inches wide, and of same material as insulation jacket. Secure with adhesive and outward clinching staples along both edges of butt strip and space 4 inches on center.
3. Longitudinal Seams: Overlap seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches on center.

    a. Exception: Do not staple longitudinal laps on insulation applied to piping systems with surface temperatures at or below 35 deg F.

4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints, over staples, and at ends butt to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor barrier coating.
6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere, staple, and seal. Extend patch at least 2 inches in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

F. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

G. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall or partition. Secure

aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer. Refer to Section 07920, "Joint Sealants."

H. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with firestopping or fire-resistant joint sealer. Refer to Division 7 for fire-stopping and fire-resistant joint sealers.

I. Flanges, Fittings, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight. Bond with adhesive.

1. Use same material and thickness as adjacent pipe insulation.
2. Overlap nesting insulation by 2 inches or 1-pipe diameter, whichever is greater.
3. Apply materials with adhesive, fill voids with mineral fiber insulating cement. Secure with wire or tape.
4. Insulate elbows and tees smaller than 3 inches pipe size with premolded insulation.
5. Insulate elbows and tees 3 inches and larger with premolded insulation or insulation material segments. Use at least 3 segments for each elbow.
6. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.
7. Cover insulation, except for metal jacketed insulation, with 2 layers of lagging adhesive to a minimum thickness of 1/16 inch. Install glass cloth between layers. Overlap adjacent insulation by 2 inches in both directions from joint with glass cloth and lagging adhesive.

J. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. Install saddles, shields, and inserts as specified in Division 15 Section 15145 “Hangers and Supports.” For cold surface piping, extend insulation on anchor legs a minimum of 12 inches and taper and seal insulation ends.

1. Inserts and Shields: Cover hanger inserts and shields with jacket material matching adjacent pipe insulation.

3.4 GLASS FIBER PIPE INSULATION INSTALLATION

A. Bond insulation to pipe with lagging adhesive.

B. Seal exposed ends with lagging adhesive.

C. Seal seams and joints with vapor barrier compound.

3.5 CELLULAR GLASS PIPE INSULATION INSTALLATION

A. Cellular Glass Insulation: Join sections of cellular glass insulation with vapor barrier compound. Secure insulation with manufacturer's recommended adhesive. Seal joints with manufacturer's recommended joint sealer.

1. Multiple Layer Installations: Stagger joints of multilayer installations. Secure inner layer with glass fiber reinforced tape. Secure outer layers with 2 metal bands for each insulation section.
2. Finishing: Apply PVC jacket over manufacturer's recommended vapor barrier mastic.

3.6 FLEXIBLE ELASTOMERIC CELLULAR PIPE INSULATION INSTALLATION

A. Slip insulation on the pipe before making connections wherever possible. Seal joints with adhesive. Where the slip-on technique is not possible, cut one side longitudinally and apply to the pipe. Seal seams and joints with adhesive.

B. Valves, Fittings, and Flanges: Cut insulation segments from pipe or sheet insulation. Bond to valve, fitting, and flange and seal joints with adhesive.

1. Miter cut materials to cover soldered elbows and tees.
2. Fabricate sleeve fitting covers from flexible elastomeric cellular insulation for screwed valves, fittings, and specialties. Miter cut materials. Overlap adjoining pipe insulation.

3.7 EQUIPMENT INSULATION INSTALLATION, GENERAL

A. Install board and block materials with a minimum dimension of 12 inches and a maximum dimension of 48 inches.

B. Groove and score insulation materials as required to fit as closely as possible to the equipment and to fit contours of equipment. Stagger end joints.

C. Insulation Thicknesses Greater than 2 Inches: Install insulation in multiple layers with staggered joints.

D. Bevel insulation edges for cylindrical surfaces for tight joint.

E. Secure sections of insulation in place with wire or bands spaced at 9 inches centers, except for flexible elastomeric cellular insulation.

F. Protect exposed corners with corner angles under wires and bands.

G. Removable Insulation: Install insulation on components that require periodic inspecting, cleaning, and repairing for easy removal and replacement without damage to adjacent insulation.

H. Stagger joints on both single and double layers of insulation.

I. Finishing: Except for flexible elastomeric cellular insulation, apply 2 coats of vapor barrier compound to a minimum thickness of 1/16 inch. Install a layer of glass cloth embedded between layers. Fill in scored block, seams, chipped edges, and depressions, and cover over with wire netting and joints with cement of sufficient thickness to remove surface irregularities.

3.8 DUCT INSULATION

A. Do not extend duct coverings through walls or floors required to be fire stopped or to have a fire resistant rating. Interrupt duct coverings in the immediate vicinity of electric resistance heaters.

B. Except where otherwise indicated, omit external insulation on internally insulated ductwork or where sound absorbing linings have been installed.

C. Install insulation materials with smooth even surfaces.

D. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor barrier on ductwork insulation and protect it to prevent puncture and other damage.

F. Insulate standing seams and stiffeners which protrude through the insulation with 0.6 pound per cubic foot density, 1-1/2 inch thick, unfaced, flexible blanket insulation. As a vapor seal, use 8 ounce canvas with vapor barrier coating. Insulation shall not prevent adjustment of damper operators or duct mounted controls.

G. Install block and board insulation as follows:

1. Adhesive and Band Attachment: Secure block and board insulation tight and smooth with at least 50 percent coverage of adhesive. Install bands spaced 12 inches apart. Protect insulation under bands and at exterior corners with metal corner angles. Fill joints, seams, and chipped edges with vapor barrier compound.
2. Speed Washers Attachment: Secure insulation tight and smooth with speed washers and welded pins. Space anchor pins 18 inches apart each way and 3 inches from insulation joints. Apply vapor barrier coating compound to insulation in contact, open joints, breaks, punctures, and voids in insulation.

H. Blanket Insulation: Install tight and smooth. Secure to ducts having long sides or diameters as follows:

1. Smaller Than 24 Inches: Bonding adhesive applied in 6 inches wide transverse strips on 12 inches centers.
2. 24 Inches and Larger: Anchor pins spaced 12 inches apart each way. Apply bonding adhesive to prevent sagging of the insulation.

3. Overlap joints 3 inches.
4. Seal joints, breaks, and punctures with vapor barrier compound.

3.9 JACKETS

A. Insulation for Interior Exposed Piping, Valves, and Fittings: Install continuous PVC jackets.

B. Install the PVC jacket with 1 inch overlap at longitudinal and butt joints and seal with adhesive.

C. When the insulation is jacketed in PVC, install a length of 40 pound roofing felt 2 inches longer than the insulation shield between the shield and jacket. Where pipe hangers or anchors are in

direct contact with pipe, seal off the pipe insulation on both sides on the hanger by carrying the vapor seal down to the bare pipe. Apply insulation vapor barrier upward and outward along the hanger rod and anchor members to a point not less than 12 inches from adjacent pipe. Draw wire loops tight over the vapor barrier jacket, with ends of wire bent down. Take care to avoid puncturing the vapor seal. Finish insulation as specified for flanges and seal over adjacent vapor barrier jacket. Install PVC jacket according to manufacturer's instructions using butt straps or slip clips.

D. Install glass cloth jacket directly over insulation. On insulation with a factory applied jacket, install the glass cloth jacket over the factory applied jacket. Install jacket drawn smooth and tight with a 2 inch overlap at joints. Embed glass cloth between (2) 1/16 inch thick coats of lagging adhesive. Completely encapsulate the insulation with the jacket, leaving no exposed raw insulation.

3.10 FINISHES

A. Paint finished insulation as specified in Division 9 Section 09900 "Painting."

B. Flexible Elastomeric Cellular Insulation: After adhesive has fully cured, apply 2 coats of protective coating to exposed insulation.

C. Install insulation on concealed round and rectangular ductwork in accordance with the manufacturer's recommendations and the following:

1. Cut insulation slightly longer than the duct perimeter to ensure full thickness.
2. Apply insulation with edges tightly butted. Adhere overlap with adhesive and flare door staples on 2 inch centers so that insulation conforms to the duct surfaces uniformly and firmly.
3. Cover seams, joints and other breaks with coating reinforced with glass fabric or a 3 inch strip of 8 ounce canvas adhered with adhesive.

3.11 PROTECTION OF INSULATION

A. Protect insulation work during the remainder of construction period to avoid damage and deterioration.

3.12 APPLICATIONS

A. General: Materials and thicknesses are specified in schedules at the end of this Section.

B. Interior, Exposed Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Domestic cold water.
2. Storm water. Insulate only roof drain bodies and horizontal rainwater leaders of storm water piping.
3. Domestic hot water.
4. Sanitary drains for fixtures accessible to the disabled.
5. Hydronic piping including chilled water, (35 to 99 deg F).
6. Hydronic piping including hot water heating, (100 to 250 deg F).

C. Interior, Concealed Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Domestic cold water.
2. Storm water. Insulate only roof drain bodies and horizontal rainwater leaders of storm water piping.
3. Domestic hot water.
4. Hydronic piping, including chilled water, (35 to 99 deg F).
5. Hydronic piping, including hot water heating, (100 to 250 deg F).

D. Duct Systems: Unless otherwise indicated, insulate the following duct systems:

1. Interior concealed supply, return and outside air ductwork.
2. Interior exposed supply, return and outside air ductwork.
3. Interior exposed and concealed supply fans, air handling unit casings and outside air plenums.

3.13 PIPE INSULATION SCHEDULES

A. General: Abbreviations used in the following schedules include:

1. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.
2. Pipe Sizes: NPS - Nominal Pipe Size.
3. Concealed piping insulation does not require jacketing.

B. Domestic Cold Water and Storm Water All Sizes (Interior): 1/2 inch thick glass fiber, cellular glass, or flexible elastomeric insulation. Field-applied jacket is not required.

C. Each Schedule will be complete on a single page. Blank spaces at the end of a page do not necessarily indicate the end of this Section.

INTERIOR DOMESTIC HOT WATER

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
1/2 TO 1-1/4	GLASS FIBER	1	NO	P
1-1/2 TO 4	GLASS FIBER	1	NO	P
5 TO 10	GLASS FIBER	1-1/2	NO	P

SANITARY DRAINS AND TRAPS EXPOSED AT FIXTURES FOR DISABLED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
1 TO 1-1/2	GLASS FIBER	1	NO	NONE
	FLEXIBLE ELASTOMERIC	1/2	NO	NONE

INTERIOR CHILLED AND DOMESTIC COLD WATER EXPOSED AND CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
1/2 TO 1-1/4	CELLULAR GLASS	1	YES	P
1-1/2 TO 4	CELLULAR GLASS	1-1/2	YES	P
5 TO 10	CELLULAR GLASS	1-1/2	YES	P

INTERIOR HYDRONIC (100 TO 250 DEG F) EXPOSED AND CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
1/2 TO 4	CELLULAR GLASS	1-1/2	NO	P

3.14 DUCT SYSTEMS INSULATION SCHEDULE

INTERIOR CONCEALED AND EXPOSED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
GLASS FIBER	BLANKET	2	YES	K

INTERIOR EXPOSED HVAC CASING, AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD- APPLIED JACKET
GLASS FIBER	BOARD	2	YES	K

END OF SECTION 15250

Acceptance Test Procedure

PROPERTY NAME:	Viking Firecycle 3 Suppression System at ZSE Air Route Traffic Control Center
PROPERTY ADDRESS:	Auburn, WA
PROJECT MANAGER:	Ken Bloom 253-351-3776
SYSTEM:	Viking Firecyle III Zone X
DATE:	_____
CONTRACTOR:	

1.0 SCOPE:

1.1 This Acceptance Test Procedure (ATP) describes the functional tests required to verify that the installed fire protection system functions as intended by the design drawings and contract specifications.

2.0 RESPONSIBILITIES:

2.1 Before requesting final approval of the installation, where required by the authority having jurisdiction, the installing contractor shall furnish a written statement to the effect that the system has been installed and tested in accordance with approved plans and tested in accordance with the manufacturer's specification and appropriate NFPA requirements.

2.2 Inspection, testing and maintenance programs shall satisfy the requirements of NFPA and the equipment manufacturer's instructions.

2.3 Nothing in this test procedure is intended to prevent the use of other test methods or testing devices provided those other methods or devices are equivalent in effectiveness and safety and meet the intent of the requirements of NFPA and the Authority Having Jurisdiction (AHJ).

2.4 A Record of Completion shall be completed for each system per NFPA 72. A preliminary copy of the certificate shall be given to the system owner and, when requested, other authorities having jurisdiction, after completion of the installation wiring tests and the final copy after completion of the operation acceptance test.

2.5 Should any of the approval party's object to the results obtained during the acceptance testing contractor's Field Engineer is to be notified. Any such notice issued verbally shall be confirmed in writing within forty-eight (48) hours after performance of that portion of the test to which exception is taken. The notice shall summarize the objection(s) and shall state the reasons for same.

2.6 Contractor shall provide all material and equipment required to perform the test (exceptions noted).

3.0 TEST PREPARTIONS:

3.1 EQUIPMENT REQUIRED:

3.1.1 Visible Smoke Source

3.1.2 Heat Gun

3.2 TEST METHODS-GENERAL:

3.2.1 Spray canned smoke into detection chamber of detector when testing.

3.2.2 Use VOM to test electrical measurements.

3.2.3 Use Heat gun to activate heat detector.

3.3 TEST CONDITIONS-GENERAL:

3.3.1 Notify interested parties of planned beginning of system tests.

3.3.2 Visually inspect the installation of all equipment to verify it is properly mounted per manufacturer's instructions.

Firecyle 3 Panels Verify { } _____ / _____ Initials / Date

Initiating Devices Verify { } _____ / _____ Initials / Date

3.3.3 Measure stray voltages between all conductors and between all conductors and ground using a multimeter on AC and DC scales. Follow these steps for all circuits listed below. Stray voltages shall not exceed 1 volt.

Firecycle Heats Verify { } _____ / _____ Initials / Date

Supervisory 1 Verify { } _____ / _____ Initials / Date

Low Air Alarm Verify { } _____ / _____ Initials / Date

Solenoid #3 Verify { } _____ / _____ Initials / Date

Solenoid #4 Verify { } _____ / _____ Initials / Date

3.3.4 Place the test leads of a multimeter across the Firecycle loop wiring to measure and record loop resistance.

Firecycle Loop Resistance_____ Ohms Verify { }
_____ / _____ Initials / Date

3.3.5 Verify that the system is in the normal supervisory condition (power lamp is "on" and all other lamps are "off").

Verify { } _____ / _____ Initials / Date

3.4 CONDUCTORS-GENERAL

3.4.1Ensure each conductor is not terminated at the main panel during test. Using a multimeter verify that all conductors not intentionally grounded are free from grounds. Place the test leads between the positive output/input wire and chassis ground, then the negative output/input wire and chassis ground. Check all circuits listed.

Firecycle (+):___ ohms Verify { } _____ / _____ Initials / Date

Firecycle (-):___ ohms Verify { } _____ / _____ Initials / Date

Supervisory 1(+):___ohms Verify { } _____ / _____ Initials / Date

Supervisory 1(-):___ohms Verify { } _____ / _____ Initials / Date

Low Air (+):___ohms Verify { } _____ / _____ Initials / Date

Low Air (-):___ohms Verify { } _____ / _____ Initials / Date

Solenoid #3 (+):___ohms Verify { } _____ / _____ Initials / Date

Solenoid #3 (-):___ohms Verify { } _____ / _____ Initials / Date

Solenoid #4 (+):___ohms Verify { } _____ / _____ Initials / Date

Solenoid #4 (-):___ohms Verify { } _____ / _____ Initials / Date

4.0 ACCEPTANCE TEST – TROUBLE CONITIONS:

4.1 DESCRIPTION OF EVENTS: For each trouble condition listed the appropriate response should occur. After completion of each test check off each step.

Perform the following to verify control panel trouble conditions:

4.1.1 Verify supervision of primary and battery power on main panel. Verify panel's trouble LED is not lit. Remove the power and verify that the trouble LED is illuminated, and proper message displays on screen. Apply primary power and verify trouble LED is not lit. Remove batter and verify trouble LED is illuminated, apply battery and verify trouble LED is not lit.

Primary power Verify { } _____ / _____ Initials / Date

Battery Verify { } _____ / _____ Initials / Date

4.1.2 Verify that all lamps and LEDs are functional.

Firecycle LEDS

Alarm Verify { } _____ / _____ Initials / Date

Supervisory Verify { } _____ / _____ Initials / Date

Trouble Verify{ } _____ / _____ Initials / Date

Power Verify { } _____ / _____ Initials / Date

5.0 ACCEPTANCE TESTS-ALARM CONDITIONS

5.1 DESCRIPTION OF EVENTS: For each alarm condition listed the appropriate response should occur. Check off each step in the space provided. After initiation of each alarm condition the following steps should be completed:

5.1.1 Static pressure set to 40 psi 24 hours prior to test. Verify { } _____ / _____ Initials / Date

5.1.2 Static pressure at 40 psi. Verify { } _____ / _____ Initials / Date

5.1.3 Activate Firecycle alarm zone, verify activation of solenoid #3 and solenoid #4 .Deactivate Firecycle alarm zone, record time .Soak timer should be set to 5min.

Time ____ min Verify { } _____ / _____ Initials / Date

5.1.4 Firecycle heats shall be cycled not less than 3 times.

Verify { } _____ / _____ Initials / Date

5.1.5 Reset the control panel after the alarm condition responses have been verified

5.1.6 Test 10% of existing building Fire Alarm system.

Verify { } _____ / _____ Initials / Date

5.2 LAYOUT: Verify device locations per approved layouts.

Verify { } _____ / _____ Initials / Date

6.0 BATTERY TEST

6.1 Visually inspect batteries for general condition. There shall be no visible discrepancies.

Verify{ } _____ / _____ Initials / Date

6.2 Verify battery-charging circuit is producing the desired output.

_____ VDC (24.0-28.0 VDC) Verify{ } _____ / _____ Initials / Date

6.3 Verify battery voltage in Firecycle panel.

_____ VDC (24.0-28.0 VDC) Verify{ } _____ / _____ Initials / Date

6.5 Remove the 120 VAC from the Firecycle Panel.

.

6.6 Record battery voltage.

_____ VDC (210-30 VDC) Verify { } _____ / _____ Initials / Date

6.7 Reset fire alarm control panel and restore 120Vac to Firecycle panel.

7.0 ALARM SIGNAL TRANSMISSION

7.1 Send a Trouble alarm to the building FACP. Verify that the signal is received.

Verify{ } _____ / _____ Initials / Date

7.2 Send an Alarm to the building FACP. Verify that the signal is received.

Verify { } _____ / _____ Initials / Date

7.3 Send a Supervisory to the building FACP. Verify that the signal is received.

Verify { } _____ / _____ Initials / Date

7.4 Send a Water flow to the building FACP. Verify that the signal is received.

Verify { } _____ / _____ Initials / Date

8.0 SECURE FROM SYSTEM TEST.

8.1 Reset system to Normal operation.
8.2 Complete and sign ATP.

ACCEPTANCE TEST PROCEDURE

EXCEPTIONS:

_____

_____

_____

_____

_____

_____

_____

WITNESS:_____ DATE:_____

WITNESS:_____ DATE:_____

APPROVED W/ EXCEPTIONS:_____ DATE:_____

APPROVED & ACCEPTED:_____ DATE:_____

GUARDIAN SECURITY SYSTEM
INSTALLATION SUPERVISOR: _____ DATE:
_____

SECTION 15325 - AUTOMATIC ON/OFF FIRE SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the minimum requirements for designing, furnishing, installing, inspecting, and testing of all equipment, materials, controls, devices, and appurtenances by a state licensed Fire Protection Installer for a fully automatic on/off fire sprinkler system (Viking Firecycle III with TRIMPAC). Included are shop drawings, hydraulic calculations, system equipment, supports (panel, trim, piping, equipment, etc.), sprinkler heads and alarm devices. This specification applies only to the aboveground part of the system, starting from existing fire main.

B. The sprinkler system shall be designed, installed, and tested in accordance with NFPA 13 and this specification. The on/off system shall provide alarm and supervisory devices in accordance with NFPA 13 and this specification.

C. The on/off system shall be designed in accordance with the hazard classifications indicated in the project drawings. Where the hazard classification is not listed in the project drawings, the system shall be designed with a hazard classification in accordance with NFPA 13. The on/off sprinkler system shall be hydraulically designed in accordance with NFPA 13 requirements.

D. Supports and brackets (panel, trim, piping, equipment, etc.) shall be designed and installed in accordance with NFPA 13. Sprinkler system piping shall be seismically protected in accordance with NFPA 13. Seismic design shall also include expansion joints where needed as determined by a licensed Professional Engineer hired by the General Contractor.

E. System drain lines shall be connected to existing drain header.

F. Related Sections:

1. Section 01300, "Submittals".
2. Section 02070, "Selective Demolition".
3. Section 07270, "Firestopping" for fire barrier sealers.
4. Section 15050, "Basic Mechanical Materials and Methods" for compressed air piping.
5. Section 15070, "Mechanical Vibration and Seismic Controls."

G. Conflicting requirements: In the case of a conflict between this specification, applicable codes, accompanying drawings, and other supplemental specifications, the Contractor shall submit the matter in writing to the COR, who will provide written clarification.

H. Electric alarm equipment shall be provided under this Section. Connection of control panels and heat detectors shall be performed in accordance with Division 13.

1.2 REFERENCE STANDARDS

A. General: The current issues of the following documents, in effect on the date of the invitation for bid, form a part of this specification and are applicable to the extent specified herein.

B American Society for Testing and Materials (ASTM)

1. A53: Specification for welded and seamless steel pipe.
2. A153: Specification for electrical resistance welded steel pipe.
3. A795: Specification for black and hot-dipped zinc coated (galvanized) welded and seamless steel pipe for fire protection use.
4. E119: Standard test methods for fire tests of building construction and materials.

C. National Fire Protection Association (NFPA)

1. 13: Installation of sprinkler systems.
2. 25: Standard for inspection, testing and maintenance of water based fire protection systems.
3. 51B: Standard for fire prevention in use of cutting and welding processes.
4. 70: National Electrical Code.
5. 72: National Fire Alarm Code.

D. American National Standards Institute (ANSI)

1. B31.1: Power piping.
2. B16.3: Malleable iron threaded fittings.
3. B16.4: Cast iron threaded fittings.
4. B16.5: Steel pipe flanges and flanged fittings.
5. B16.9: Factory made wrought steel buttwelding fittings.
6. B16.21: Nonmetallic flat gaskets for pipe flanges.
7. B1.20.1: Pipe threads, general purpose.
8. B36.10M:Wrought steel pipe.

E. National Electrical Manufacturers Association (NEMA)

1. 250: Enclosures for electrical equipment.

F. Underwriters Laboratories (UL)

1. Fire Protection Equipment Directory.

G. Factory Mutual Research (FMR)

1. Approval Guide.

1.3 DEFINITIONS

A. Working plans as used in this Section refer to documents (including drawings and calculations) prepared pursuant to requirements in NFPA 13 for obtaining approval of authority having jurisdiction.

B. Other definitions for fire protection systems are included in referenced NFPA standards.

1.4 SYSTEM DESCRIPTION

A. General: The on/off sprinkler system shall be configured for fully automatic actuation and shutdown cyclical operation as a cycling single interlocked preaction system. System shall be a single interlocked system comprised of flow control valves capable of automatic open/close operation, air/water trim lines incorporating solenoid valves and pressure switches, check valve, sprinkler system piping and sprinklers. The system shall include a self-contained closed circuit detection system comprised of resetting heat detectors, fire control panel timer and back-up battery source power supply.

B. Sprinkler System Protection Limits: Spaces within areas indicated on the contract drawings. Include closets, the top landing of each stair, and special applications areas.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

A. Design and obtain approval from COR for fire protection systems specified.

B. The fire protection system shall be hydraulically designed to operate with a safety factor of 7 psi. Hydraulic information shall be measured at the point of connection prior to designing the system.

C. Hydraulically Design Sprinkler Systems according to Sprinkler System Occupancy Hazard Classifications:

1. Office, Computer and Public Areas: Light hazard.
2. Storage Areas: Ordinary hazard, Group 1.
3. Equipment Rooms and Mechanical Rooms: Ordinary hazard, Group 1.
4. Service Areas: Ordinary hazard, Group 1.

D. Minimum Density Requirements for Automatic Sprinkler System Hydraulic Design:

1. Light Hazard: 0.10 GPM over 1500 sq. ft. area.
2. Ordinary Hazard, Group 1: 0.15 GPM over 1500 sq. ft. area.

E. Maximum Protection Area of Coverage per Sprinkler shall be in Accordance with the Value indicated in NFPA 13:

1. Light Hazard: 225 sq. ft. / sprinkler.
2. Ordinary Hazard, Group 1: 130 sq. ft. / sprinkler.

F. Components and Installation: UL listed for the following maximum working pressure ratings except where indicated otherwise.

1. Sprinkler Systems: 175 psig.

1.6 SUBMITTALS

A. Product Data for Fire Protection System Components:

1. Sprinkler piping and fittings.
2. Valves.
3. Specialty valves, accessories, and devices.
4. Alarm and supervisory devices. Include electrical data.
5. Heat detector, detector cable and conduit.
6. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other data.
7. Releasing panel.
8. Hangers and bracing.

B. Installer qualification: Submit proof that the installer meets the specified qualifications.

C. Shop Drawings: Submit piping layout, hydraulic and battery calculations for approval. Show dimensions, locations of sprinklers, fittings, hangers, accessories and other similar items of the system. Show instrumentation and piping schematics. In addition, submit heat detector layout drawings showing heat detector locations, conduit paths, conduit sizes and quantity of conductors. Drawings shall conform to the requirements of NFPA 13 for Working Plans. Hydraulic calculations shall conform to requirements of NFPA 13 for Hydraulic Calculation Forms. Drawings shall be sealed by a NICET (National Institute for Certification of Engineering Technologies) Level IV suppression systems technician or Licensed Professional Engineer.

D. Material and Equipment Conformance: Where materials and equipment are specified to conform to requirements of ANSI, ASTM, FM, NFPA or UL, submit proof of such conformance. The label or listing of the specified agency will be acceptable evidence.

E. Welders Certification: Submit welder's certification in accordance with ANSI B31.1, Chapter V.

F. Welding Procedures: Submit welding procedures qualified in accordance with ANSI B31.1, Chapter V.

G. Piping Hanger Schedule: Submit schedule showing location and details of pipe supports, including seismic bracing.

H. Documentation of NICET Level IV certification as a sprinkler designer or registration as a Licensed Professional Engineer for the designer.

I. Test reports and certificates as described in NFPA 13 and Part 3 of this Section. Include "Contractor's Material & Test Certificate for Aboveground Piping".

J. Maintenance data for each type of fire protection specialty specified, for inclusion in Operating and Maintenance Manual.

K. Two (2) copies of the latest edition of NFPA 13 " Installation of Sprinkler Systems." Deliver to Owner's maintenance personnel.

L. Two (2) copies of the latest edition of NFPA 25 "Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems." Deliver to Owner's maintenance personnel.

M. Record Drawings: Contractor shall provide one set of Record Drawings immediately upon completion of sprinkler system installation as part of Operating and Maintenance Manuals. Include closet layout, layout of piping mains and branches, instrumentations, valves, sprinklers, and other components.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL Fire Protection Equipment Directory and FM Approval Guide and that conform to other requirements indicated.

B. Listing/Approval Stamp, Label, or Other Marking: On equipment, specialties, and accessories made to specified standards.

C. Sprinkler system design and calculations shall be prepared by a NICET (National Institute for Certification of Engineering Technologies) Level IV technician, or a Licensed Professional Engineer.

D. Sprinkler piping shall be shop welded per NFPA 13. If piping must be welded in place, welding shall be performed in accordance with NFPA 51B and shall be pre-approved in writing by the COR.

E. Listing and Labeling: Equipment, specialties, and accessories that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in "National Electrical Code," Article 100 and NFPA 13.
2. Listing and Labeling Agency Qualifications: “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

F. Installers Qualifications: Firms qualified to install and alter fire protection piping, equipment, specialties, and accessories, and repair and service equipment. A qualified firm is one that is experienced (minimum of 5 previous projects similar in size and scope to this Project) in such work, familiar with precautions required, and in compliance with the requirements of the authority having jurisdiction. Submit evidence of qualification to the COR upon request.

1.8 OPERATION

A. In non-operational conditions, the system piping shall be air pressurized to the check valve outlet side. Pressurized water from the trim priming line is employed in the top chamber of the flow control valve to maintain a closed clapper. Detection circuits are energized at all times maintaining closed solenoid valves in the trim lines. Should a heat detector actuate, the break contact circuit action de-energizes and opens the solenoid valves in the on/off fire sprinkler system trim lines. This releases the top chamber pressure, the clapper opens, water issues from the discharge chamber and the resulting increase in piping system air pressure activates the pressure switches for alarm purposes. Once the temperature is sufficient, sprinklers activate as normal, and water is discharged over the affected area. When the temperature drops sufficiently, the heat detector resets itself energizing the timer unit. Water continues to flow from the system until the set time period is exceeded. At that time, the solenoid valves are re-energized to closed condition and the flow control valve clapper is closed as the pressure builds up. Alarm resetting shall be done manually on the control panel. This cycle shall repeat until such time as the fire condition is eliminated. Loss of air pressure in sprinkler system piping network shall not open the solenoid valve.

B. For each pre-action fire suppression system, monitoring points shall be installed on the existing ARTCC fire alarm system to directly monitor the points below:

1. System Trouble (TB3)
2. Zone Relay Module Supervisory (TB1 - Terminals 4 & 6)

3. Zone Relay Module Alarm (TB1 - Terminals 13 & 15)
4. System Isolation Valve (Directly to the FACP)
5. System Test Isolation Valve (Directly to the FACP)
6. System Flow Pressure Switch (Directly to the FACP)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials: Materials and equipment shall be new, and shall conform to the types and sizes required by NFPA 13 for uses shown. The on/off sprinkler system shall be listed as a complete assembly in the UL Fire Protection Directory under the classification A Special System Water Control Valves B Flow Cycling Assemblies (VLLA). Other components shall be UL listed or FM approved. Each item shall function for extended periods of time with limited maintenance.

B. Control Panel: The control panel shall be a programmable microprocessor controlled releasing panel. The on/off system control shall be fully self-contained and shall incorporate all circuitry, relays, switches, fuses; alarm horn, timer, and trouble lamps for complete control of the on/off fire sprinkler system. The control panel shall have the capability to connect to a normally closed initiating device circuit configured as a Class B circuit. The control panel shall include a soak timer that allows flow to continue for an adjustable time period (initially set at 60 seconds) after the heat detectors have reset. The soak timer shall be adjustable from 30 seconds to 15 minutes (initially set at 60 second). The panel shall be wired to incorporate an emergency back-up power supply in addition to the primary main power source. The latter is to be 115 Volt/60Hertz. The panel shall have a vented enclosure and shall incorporate a full face locking front located door. The enclosure shall be painted red and shall incorporate wall-mounting lugs. The panel shall include two auxiliary dry form C contacts for alarm and trouble outputs to the fire detection system. The contacts shall be rated for 2 amps at 30 V AC resistive.

1. Acceptable Source: Viking Firecycle III VFR400 Control Panel with Firecycle III TRIMPAC.

C. Back-Up Power Supply: The emergency back-up power supply shall be comprised of a minimum of two appropriately sized 12 V rechargeable batteries connected in series to attain the 24 VDC required by the release system. Batteries shall be of the sealed lead acid type. Batteries shall be capable of operating system in the standby mode for 24 hours and alarm mode of 2 hours at the end of the standby period or, provide 12 amp-hour batteries, whichever is greater.

D. Heat Detectors: On/off system heat detectors shall be the fixed temperature, normally closed, automatic resetting type. Nominal temperature rating shall be per the manufacturer recommendation for the temperature rating of the sprinklers used. The detector shall have an

aluminum conduit connection housing, stainless steel heat probe and zinc alloy telltale. Electrical rating shall be 125 VAC, 14 amps.

1. Known Acceptable Source: Viking Model B.

E. Heat Detector Cable: High temperature, flame resistant detector cable shall be a UL listed Power Limited Fire Protection Signaling Cable and shall be installed in rigid steel conduit. Conductor shall be two (2) 16 AWG solid bare soft copper. Insulation shall be silicon rubber and jacket shall be thermoplastic with zero halogen for use in rigid steel conduit. Aluminum sheathed cable is not acceptable.

1. Known Acceptable Source: Viking Firecycle III Technical Data Sheet 419A.

F. Solenoid valves: On/off system solenoid release valves shall be constructed of a 1/2 inch brass body; with a stainless steel core, core tube, plugnut and springs. Solenoid valve shall have a maximum working pressure of 175 psi. Electrical rating shall be 24 VDC. There shall be one normally closed and one normally open solenoid valve as required for a cycling single interlock preaction system. Solenoid valves shall be listed for use with the flow control valves.

G. System check valves: The on/off system check valve shall be a combination swing-check/drain unit for use in a system riser. Body shall be ductile iron with flanged or grooved end connections. The swing clapper rubber shall be EPDM. With the exception of the seat, which shall be brass, other internal parts shall be stainless steel, as shall be the access plate. The body shall be tapped 3 inch NPT for drain connection (2-1/2 inch NPT for 2-1/2 inch valve); 1/2 inch NPT for air release connection to the solenoid valves; 1/4 inch NPT for pressure gage connection.

1. Known Acceptable Source: Viking Model E-1 or F-1.

H. System valves and System Isolation Valves: The system valves shall be OS&Y gate or butterfly type, for use in piping 2 1/2 inches and larger, with a working pressure rating of 175 psi. Valves shall be UL listed and FM approved for use in fire protection systems. Valves shall include manual operator with handwheel and tamper switch.

1. OS&Y gate valves: OS&Y gate valve, with iron body, designed to fit between ANSI B16.5, Class 150 flanges.

2. Butterfly valves: Wafer-Body designed to fit between ANSI B16.5, Class 150 flanges.

I. Angle valves: Drain and trim angle valves shall be screwed bronze body rising stem with screw-in bonnet.

J. Flow Control Valve: The flow control valve shall be of the configuration application intended, quick opening differential diaphragm type with a spring loaded floating clapper. Valve shall

be capable of automatic on/off control through trim lines specifically designed for an on/off type sprinkler system. Diaphragm and seat rubbers shall be field replaceable. Valve body and cover shall be ductile iron and be tapped for all required drain and trim connections. Diaphragm and seat rubbers shall be EPDM. Retaining screws, spring and seat rubber reinforcing ring shall be stainless steel. The clapper, damp ring and seat shall be bronze. The flow control valve shall be provided with the necessary trim package required by the manufacturer for use on a cycling single interlocked preaction system.

1. Known Acceptable Source: Viking Model H-1.

K. Auto ball drip: Trim and drain auto drip valves shall be 1/2-inch bronze body.

1. Known Acceptable Source: Viking Technical Data Sheet 829B.

L. Ball Valve (compressed air): 2 inches and smaller. Cast bronze body conforming to ASTM B584 with stainless steel ball and reinforced 15 percent glass fill seal, stems made from brass conforming to ASTM B16. Designed for 150-psi non-shock working pressure.

M. Identification signs: Signs shall be made of a durable metal that can withstand the ambient conditions at the job site. Signs shall have a red background with white lettering as outlined in NFPA 13. Signs shall be provided for alarm valve, system riser, auxiliary drain, inspectors test, main drain, and auto sprinkler.

N. Sprinklers:

1. Sprinklers shall be UL listed or FM approved, with 175-psig minimum pressure rating.
2. Automatic Sprinklers: With heat-responsive element complying with UL 199, “Standard for Automatic Sprinklers for Fire-Protection Service”.
3. Sprinkler shall be upright, pendant (concealed) or sidewall type for the specific application. Where conditions require, temperature ratings shall be increased to intermediate or high levels as indicated in NFPA 13.
   a. Alternate sprinkler type: Sprinkler shall be pendant (recessed) type for the specific application. Where conditions require, temperature ratings shall be increased to intermediate or high levels as indicated in NFPA 13.
4. Sprinkler Finishes: Chrome plated or bronze.
5. Sprinklers shall be quick response (as indicated for the specific application), fusible link type with a temperature rating of 165 degrees F, 1/2 inch NPT standard thread connection, brass construction, and nominal K-factor 5.6.

O. Sprinkler Cover Plate Assembly: Concealed sprinklers mounted in ceilings shall include the following:
1. Sprinkler/Support Cup Assembly.
2. Cover Plate/Retainer Assembly, including cover plate with white painted finish.

P. Sprinkler guards: Sprinklers below 7 ft above finish floor level or subject to the possibility of physical damage, shall be provided with sprinkler guards:

Q. Supervisory Components and Alarms:

1. 1. Pressure alarm switches: The pressure switch shall be compatible with the flow control valve trim. The switch shall reset automatically on pressure drop. The switch shall provide dual single pole double throw contacts and be suitable for connection to the on/off system control panel. Each switch shall be monitored by the FACP through addressable interface devices as indicated in Section 13850, "Fire Alarm and Detection System."

   a. Known Acceptable Source: Viking Model 09471.

2. Pressure supervisory switches: the pressure switch shall be compatible with the flow control valve trim. The switch shall reset automatically. The switch shall be provided with dual single pole double throw contacts and be suitable for connection to the on/off system control panel.

   a. Known Acceptable Source: Viking Model 09473.

3. Tamper switches: The tamper switch shall be used to provide supervision of the open position for all control valves. The switch shall provide single pole double throw contacts and be housed in the manufacturers standard enclosure. Each switch shall be monitored by the FACP through addressable interface devices. As indicated in Section 13850, "Fire Alarm and Detection Systems."

2.2 PIPE AND FITTINGS

A. Above ground system pipe shall be black steel, standard weight, schedule 40 for pipe below 2 ½ inches, and schedule 10, roll-grooved, for pipe 2 ½ inches and larger. Cut-grooved piping are not acceptable. Pipe 2 inches and smaller shall be threaded to ANSI B1.20.1. Pipe 2 1/2 inches and larger may be joined with mechanical grooved couplings, or flanged in accordance with ANSI B16.5. Main piping shall incorporate butt-welded fittings.

B. Fittings shall Conform as Indicated:

1. Threaded fittings: Black banded, Class 125, ANSI B16.4, or black malleable iron, Class 150, ANSI B16.3.
2. Grooved couplings and mechanical fittings: Malleable iron, 300 psi working pressure. Coupling gasket material shall be butyl rubber. Grooved couplings and mechanical fittings shall be UL listed or FM approved for the intended use. Provide flexible couplings as required by NFPA 13 for seismic protection of piping.

3. Flanged fittings: Steel 150-lb. class to B16.5. Cast iron is not acceptable. Gaskets to be red rubber 1/16 inch to ANSI B16.21.
4. Welded fittings: Wrought steel manufactured to ANSI B16.9.
5. Flexible pipe couplings required for Seismic Criteria: Shall permit 1 degree or more of angular movement at the grooved connection without harm to the pipe.

2.3 HANGERS AND SUPPORTS

A. Hangers and earthquake bracing shall be of ferrous material and shall conform to the requirements of NFPA 13.

B. Support all horizontal piping as outlined in NFPA 13. Provide swivel split ring hangers with rod supports and sway braces at every third hanger.

C. Support furred-in vertical piping by means of heavy wrought iron clamps on wall bracket or at floors. Where vertical piping is exposed, supports shall be from wrought iron clamps suspended from the underside of the slab with hanger rods.

D. Hangers shall be of a type approved by NFPA, UL, or Uniform Building Codes and be approved and acceptable to the COR for use in this type of installation.

2.4 PIPE SLEEVES AND PLATES

A. For concrete walls and floors provide ASTM A53, Type E, Grade A, schedule 40 galvanized pipe with plain ends.

B. Pipe sleeves shall be sized in accordance with seismic requirements of NFPA 13.

C. Where sleeves are installed in floors or walls with membranes provide membrane clamp.

D. Provide chrome plated brass setscrew flanges at finished floors, walls and ceilings.

2.5 PRESSURE GAGES

A. Pressure Gages: UL 393, 3-1/2 to 4-1/2 inches diameter dial with dial range of 0-250 psig.

PART 3 - EXECUTION

3.1 GENERAL

A. All parts of the on/off fire sprinkler system shall be installed so that the systems may be thoroughly drained and in accordance with commercial practices and the equipment manufacturers recommendations. Auxiliary drains at the end of branch lines are not allowed.

Piping shall be sloped so that the system drains at the main drain. If it is determined that auxiliary drains are required, they shall be piped back to a location approved by the COR.

B. On/off fire sprinkler system piping shall be installed to the slope requirements stipulated for dry pipe systems in NFPA 13. Installation of all materials and equipment shall be in accordance with NFPA 13, this specification, and as indicated.

C. Install work in such a manner that it will conform to the structure, avoid obstructions, preserve headroom, and keep openings and passageways clear.

D. Fire protection work shall in all cases, consider the work of other trades so that the best arrangement of equipment, piping, and conduit will be obtained.

E. Cutting, channeling, chasing, or drilling of floor, walls, partitions, ceilings or other surfaces, if necessary for the proper installation, support, or anchorage of the piping or other work, shall be done to prevent damage to the existing structure. Damage to building, piping, or equipment shall be repaired or refinished.

F. Pipe used shall be free of corrosion and clean. Cut pipe ends shall be burred to a smooth finish. No damaged pipe is to be installed. Grooved pipe shall be roll-grooved. Cut-grooved piping are not acceptable. Pipe welding shall be carried out at the shop. No welding of pipe in occupied spaces is permitted without express written permission from the COR. When approved, welding shall conform to requirements of NFPA 51B. This prohibition does not include the outdoor staging area. The piping system shall be thoroughly flushed clean upon completion of installation. Auxiliary drains at the end of branch lines are not allowed.

3.2 PIPE INSTALLATION

A. Piping shall be protected from damage caused by seismic conditions in accordance with NFPA 13 requirements. Metal pipe supports, hangers, sway braces, clamps, brackets, and other pipe support accessories for sprinkler system piping shall meet the requirements of NFPA 13 for Seismic criteria, and shall be suitable for forces imposed by system pressures, thermal expansion and contraction, seismic loads, and other external forces.

B. Care shall be taken when installing piping to avoid possible restrictions due to foreign matter. All piping shall be installed so that the system may be drained and flushed in accordance with NFPA 13.

C. For penetrations of concrete floors or walls sleeves shall be provided. Wall sleeves shall be cut flush with wall surfaces, and shall project 3 inches above and below floor surfaces. Sleeves may be galvanized steel or cast iron pipe, or galvanized sheet metal with longitudinal locking seam. The clearance between sprinkler piping and pipe sleeves through walls and floors shall be not less than that allowed by NFPA 13 for protection of piping against damage from earthquakes.

D. UL listed through-penetration firestop systems: Provide at sprinkler pipe penetrations through fire rated floors and walls in accordance with requirements of Section 07270, "Firestopping".

3.3 SPRINKLERS

A. Sprinklers shall be located so as to obtain the specified density and area coverage requirements for the area hazard classification. Sprinklers shall be installed only in the position for which they are designed. Pendent and sidewall sprinklers shall be installed on return bend piping arrangements. Sprinklers shall not be altered in any respect or have any type of ornamentation or coatings applied after shipment from the manufacturer. Sprinklers installed where they might receive mechanical damage shall be protected with approved guards. Sprinklers shall be placed at the center of either full or half-ceiling panels to within plus or minus 1/2-inch tolerance in panels and alignment with adjacent sprinklers.

B. Provide the following sprinkler types:

1. Rooms without ceilings: Upright sprinklers.
2. Rooms with suspended ceilings (new or existing): Concealed sprinklers.
3. Rooms with new hard ceilings: Concealed sprinklers.
4. Rooms with existing hard ceiling to remain: Concealed sprinklers.
5. Wall Mounting: Sidewall sprinklers.
6. Light Hazard Areas: quick-response sprinklers.
7. Sprinkler Finishes:

   a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view and in areas without finished ceilings.
   b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

3.4 VALVES

A. Valves shall be installed in an accessible location and in accordance with NFPA 13 requirements for pre-action systems. Tamper switches shall be provided on all water supply and control valves.

3.5 TEST AND DRAIN CONNECTIONS

A. Test connections shall be provided and installed on sprinkler systems in accordance with NFPA 13 requirements for preaction systems. The test connection valve shall be readily accessible. Provisions shall be made for piping all drain connections to the exterior or approved receptors. Splash blocks shall be provided at all drain exit locations.

3.6 HEAT DETECTORS

A. Heat detectors: Heat and smoke detectors layouts shown on the drawing is schematic in nature, contractor is to provide detectors in accordance with NFPA and manufacturers recommendations. Heat detectors and heat detector wiring shall be installed in accordance with manufacturer recommendations and NFPA 72 requirements. Support detectors from building structure. Provide pipe nipples, couplings, escutcheons, and appurtenances for each detector. In areas with suspended ceilings, the heat detectors shall be installed in the semi-recessed configuration per the manufacturer installation requirements. Heat detectors shall be located to cover an area no greater than recommended by the manufacturer for the detector furnished.

B. Coverage by a detector shall not exceed a maximum area of 1600 sq ft for smooth, flat ceilings (40 ft by 40 ft). Modify spacing per NFPA 72 criteria and manufacturers criteria for other than smooth ceilings. Coordinate detector locations with baffles, grilles, diffusers, registers, light fixtures, and other equipment. Install heat detector wiring in rigid steel conduit. The minimum size conduit, for detector wiring only, shall be 1/2 inch. All other conduit shall be a minimum of 3/4 inch.

3.7 TESTING

A. General:

1. Tests shall be static compressed air test, and the system shall be made tight such that no loss of pressure occurs during a 24 hour period when the system is pressurized at 40 psi gage.
2. All material and equipment furnished and work done will be continuously inspected by the COR. Any material, equipment, or work approved and later found to be defective shall be replaced by the Contractor at his own expense. The Contractor shall ask for approval only after his own inspection and after he is satisfied that he has met all specified requirements.
3. All tests shall be conducted as required by and in accordance with NFPA 13 requirements.
4. All tests shall be performed in the presence of the COR. Test date shall occur not sooner than 72 hours after approval of test procedure by the Government. Test procedure review period required by the Government shall be not less than 30 days. Test date scheduling shall not be submitted until test procedures have been approved.
5. Perform on/off system tests per manufacturers test procedures.

B. Testing Equipment: Equipment, material, and labor for the tests shall be provided by the Contractor. If tests, or portion thereof, fail, the Contractor shall undertake repairs immediately and retest to the satisfaction of the COR.

C. Piping System Acceptance Test:

1. After flushing with forced air the Sprinkler system piping shall be compressed air tested. The pressure shall be measured at the low point of each system or zone being tested.

2. A thorough visual inspection of the installed system and hazard area shall be performed. The piping, operational equipment and sprinklers shall be inspected for proper size, supports, and location.
3. Upon completion of the work and tests, secure approval from the COR.
4. Perform On/Off system test per manufacturers test procedures.

D. Electrical system acceptance test:

1. Verify proper operation of the automatic on/off sprinkler system control system including valves, pressure switches, indicator lights, backup power supply, heat detectors, alarm detection circuits, and alarm outputs to FACP according to manufacturers written test procedures and NFPA requirements.

3.9 CLEANING

A. Clean dirt and debris from sprinklers. Replace sprinklers having paint other than factory finish with new sprinklers. Cleaning and reuse of painted sprinklers is prohibited.

3.10 COMMISSIONING

A. Starting Procedures: Follow manufacturer's written procedures.

B. Coordinate with fire alarm system tests. Operate systems as required.

3.11 DEMONSTRATION

A. Demonstrate equipment, specialties, and accessories. Review operating and maintenance information.

B. Schedule demonstration with at least 7 days advance notice.

3.12 TRAINING

A. Engage manufacturers-authorized instructors to demonstrate and train Center maintenance personnel as specified below. Equipment installers are not acceptable instructors.

1. Prior to final acceptance provide three eight-hour sessions of operation training and trouble shooting to eight Government technicians.
2. Each training session shall include emergency procedures, system operation, troubleshooting procedures, the required periodic testing and inspection, and safety requirements.
3. Training shall cover each fire sprinkler system install or modified to Fire Cycle III.
4. Each session shall include a complete demonstration of the system. Each session shall provide identical information.

5. Submit training materials for approval at least 14 days prior to start of training.
6. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid. Provide each student with a copy of the operation and maintenance manual.

END OF SECTION 15325

SECTION 15410 - PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes plumbing piping systems within the building. Systems include the following:

1. Cold water make-up to mechanical equipment and potable water distribution.
2. Storm drainage system.
3. Condensate drain system.
4. Domestic hot and cold water piping systems.
5. Sanitary drain piping system.
6. Vacuum cleaning system

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME)

1. B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
2. B31.9 - Building Services Piping.

B. American Society for Testing and Materials (ASTM)

1. A888 – Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
2. B88 - Seamless Copper Water Tube.
3. D2665 – Standard Specification for Polyvinyl Chloride (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

C. American Water Works Association (AWWA)

1. C651 - Disinfecting Water Mains.

D. Cast Iron Soil Pipe Institute (CISPI)

1. CISPI 301 – Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
2. CISPI 310 – No-hub Couplings

1.3 SUBMITTALS

A. Product data for the following plumbing piping products:

1. Cold Water make-up piping and fittings.
2. Condensate drain piping and fittings.
3. Storm water drainage piping and fittings.
4. Domestic hot and cold water piping systems.
5. Sanitary drain piping system.
6. Vacuum cleaning system

B. Water samples, test results, and reports specified in "Field Quality Control" and "Cleaning" Articles.

C. Coordination drawings, drawn accurately to scale and coordinating penetrations.

1.4 QUALITY ASSURANCE

A. Comply with the provisions of ASME B31.9 for materials, products, and installation.

B. Provide listing/approval stamp, label, or other marking on piping made to specified standards.

PART 2 - PRODUCTS

2.1 PIPES AND TUBES

A. General: The application of pipe, tube, fitting materials, and joining methods required for plumbing piping systems are scheduled at the end of this specification.

2.2 VALVES

A. Refer to Section 15100 "Valves" for gate, globe, ball, butterfly, and check valves.

PART 3 - EXECUTION

3.1 INSTALLATION OF COLD WATER MAKE-UP PIPING AND APPURTENANCES

A. Install cold water piping with uniform horizontal grade of 1/8 inch per foot, minimum, to low points and in accordance with IPC and IMC. Where constant pitch cannot be maintained for long runs, establish intermediate low points and rise to new level. Drain grade branches to mains or risers. Unless otherwise indicated, terminate low points of risers with drain valve and run ½ inch line to nearest local authority's approved type receptor.

B. Sterilize the cold water system with a solution containing not less than 50 parts per million available chlorine. Allow chlorinating solution to remain in system for a period of 8 hours in

accordance with AWWA C651. Have valves and faucets opened and closed several times during the period. After sterilization, flush the solution from the system with clean water until the domestic water system residual chlorine level is equal to the City Service residual chlorine level entering the facility.

3.2 INSTALLATION OF STORM DRAINAGE PIPING AND APPURTENANCES

A. Slope horizontal storm drainage piping a minimum of 1/8 inch per foot in compliance with IPC.

B. Install cast-iron storm pipe and cast-iron storm pipe fittings according to ASTM A 888 and CISPI 301.

C. Make changes in direction for drainage using appropriate Y branches, Y branches with 1/8 bends, and long-sweep 1/4, 1/5, 1/6, 1/8, and 1/16 bends. Make no change in direction of flow greater than 90 degrees. Where different sizes of drainage pipes and fittings are connected, use proper size standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

D. Sleeves are not required for cast-iron storm pipes passing through concrete slab, without membrane waterproofing, on grade.

3.3 INSTALLATION OF CONDENSATE DRAIN PIPING

A. Install condensate drain piping in accordance with IPC, IMC and other applicable local codes.

B. Provide traps on air handling unit condensate drains of sufficient depth as indicated on the drawings to overcome the total static pressure of the air handling unit.

3.4 INSTALLATION OF DOMESTIC HOT AND COLD WATER PIPING

A. Install domestic hot and cold water piping systems with horizontal grade of 1/8 inch per 10 feet, minimum, to low points in accordance with IPC and IMC. Where constant pitch cannot be maintained for long runs, establish intermediate low points and rise to new level. Drain grade branches to mains or risers. Unless otherwise indicated, terminate low points of risers with drain valve and run ½ inch line to nearest local authority's approved type receptor.

B. Install temperature maintenance system on domestic hot water piping in accordance with the temperature maintenance system manufacturer's recommendations.

C. Sterilize the domestic hot and cold water system with solution containing 50 parts per million available chlorine. Allow chlorinating solution to remain in system for a period of eight hours in accordance with AWWA C651. Have valves and faucets opened and closed several times during the period. After sterilization, flush the solution from the system with clean water until residual chlorine content is equal to the City Service residual chlorine level entering the facility.

3.5 INSTALLATION OF SANITARY DRAIN PIPING SYSTEM

A. Install and support sanitary drain and vent piping in accordance with IPC.

B. Slope horizontal waste piping: 3" and smaller - slope 1/4" per foot, 4" and larger, slope 1/8" per foot.

C. Provide offsets and fittings as indicated on the drawings or as required. Use reduction fittings to connect two pipes of different diameter. Change directions by appropriate use of 45 degree wyes, long-sweep quarter bends, sixth, eighth and sixteenth bends. Sanitary tees may be used on vertical stacks. Use long sweeps at the base of risers.

D. Unless otherwise indicated, provide a separate trap at each fixture. Place traps so that the discharge from the fixture will pass through only one trap before reaching the building drain.

E. Install cleanouts of the same size as the soil waste lines in which the cleanouts are placed; however, cleanouts shall not be larger than 4 inches in diameter. Provide cleanouts where soil lines change direction, at the end of each continuous waste line, and at the base of each riser.

F. Install vent piping as indicated on the drawings or as required. Flash penetrations through the roof with 6 pound lead flashing approximately 24 inches square. Flange the flashing to the lead sleeve. Extend the flashing up and around the vent pipe. Turn the flashing down inside the pipe at least 2 inches to make an absolutely watertight joint. Coordinate requirements with architectural details.

3.6 INSTALLATION OF VALVES

A. Sectional Valves: Install sectional isolation valves in each cold water make-up branch.

3.7 FIELD QUALITY CONTROL

A. Inspect water distribution piping as follows:

1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.
2. During progress of the installation, notify COR at least 24 hours prior to time inspection must be made. Perform tests specified below in presence of the COR.

   a. Roughing-In Inspection: Arrange for inspection of piping system before concealed or closed-in after system roughing-in and prior to setting drains.
   b. Final Inspection: Arrange for final inspection by COR to observe tests specified below and to ensure compliance with requirements of plumbing code.

3. Reinspections: When COR finds that piping system will not pass test or inspection, make required corrections and arrange for reinspection by the COR.
4. Reports: Prepare inspection reports signed by COR.

B. Test water distribution piping as follows:

1. Test for leaks and defects in new water distribution piping systems and parts of existing systems that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of system tested.
2. Leave uncovered and unconcealed in new, altered, extended, or replaced water distribution piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved for testing.
3. Cap and subject the piping system to a static water pressure of 50 psig (345 kPa) above the operating pressure without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for 4 hours. Leaks and loss in test pressure constitute defects that must be repaired.
4. Repair leaks and defects with new materials and retest system or portion thereof until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

C. Inspect drainage piping as follows:

1. Do not enclose, cover, or put into operation drainage piping system until it has been inspected and approved by the COR.
2. During progress of installation, notify the COR at least 24 hours prior to time such inspection must be made. Perform tests specified below in presence of the COR.

    a. Roughing-In Inspection: Arrange for inspection of piping system after system roughing-in, before concealing, and prior to setting drains.
    b. Final Inspection: Arrange for final inspection by COR to observe tests specified below and to ensure compliance with requirements of plumbing code.

3. Reinspections: Make required corrections and arrange for reinspection by COR when piping system fails to pass test or inspection.
4. Reports: Prepare inspection reports signed by the COR.

D. Drainage Piping System Tests: Test drainage systems as follows:

1. Test for leaks and defects in new drainage piping systems and parts of existing systems that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed in new, altered, extended, or replaced drainage piping until it has been tested and approved. Expose for testing work that has been covered or concealed before it has been tested and approved.
3. Rough Plumbing Test Procedure: Test piping of plumbing drainage systems on completion of roughing-in piping installation. Tightly close all openings in piping

system and fill with water to point of overflow, but not less than 10 feet head of water. Water level shall not drop during the period from 15 minutes before inspection starts through completion of inspection. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After drains have been set, test connections and prove gastight and watertight. Plug stack openings on roof and building drain where it leaves the building and introduce air into the system equal to pressure of 1 inch water column. Air pressure shall remain constant without introducing additional air throughout period of inspection.
5. Repair leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean and disinfect water distribution piping as follows:

1. Purge new potable water distribution piping systems.
2. Use purging and disinfecting procedure described in AWWA C651, or in AWWA C652, or as specified below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill system or part thereof with water/chlorine solution containing at least 200 parts per million of chlorine. Isolate (valve off) and allow to stand for 24 hours.
c. Flush system with clean, potable water until chlorine does not remain in water coming from system following allowed standing time.
d. Employ the services of an independent testing laboratory, acceptable to the COR, to take samples and to perform analysis to determine content of microbial organisms (Bug Test). Certify that water samples are potable and are safe for drinking. In the event test results fail, repeat chlorination and retest until analysis yields acceptable results.

B. Prepare and submit reports for purging and disinfecting activities.

C. Clean interior of piping system. Remove dirt and debris as work progresses.

3.9 COMMISSIONING

A. Fill water systems.

B. Before operating systems, perform these steps:

1. Close drain valves and hose bibbs.
2. Open shutoff valves to full open position.

3. Remove plugs used during testing of piping systems and plugs used for temporary sealing of piping during installation.
4. Close drain valves and replace drain plugs.

C. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from construction work.

B. Place plugs in ends of uncompleted piping at end of day or when work stops.

3.11 PLUMBING PIPE AND FITTINGS SCHEDULE

Item	Size (Inches)	Description
Sanitary sewer and vent pipe, and fittings	All sizes	Polyvinyl chloride (PVC) plastic pipe, Schedule 40, Type DWV (ASTM D2665)
Sanitary sewer and vent stack pipe and fittings (ONLY applies to main vertical 4” sanitary sewer and vent stack)	4” and above (ONLY applies to main vertical 4” sanitary sewer and vent stack)	Cast iron hubless pipe (ASTM A 888 and CISPI 301); Fittings: No-hub coupling (CISPI 310), stainless steel shield and clamp assembly with elastomeric sealing sleeve (ASTM C-564)
Domestic hot and cold water pipe and fittings	All sizes	Copper tubing, Type L (ASTM B88); Fittings: Wrought copper (ASME B16.22) with soldered joints (95-5 tin-antimony)
Cleanouts	4” and smaller	Commercial grade, Schedule 40 PVC, with removable plug.
Condensate drain	All sizes	Copper tubing, Type L (ASTM B88); Fittings: Wrought copper (ASME B16.22) with soldered joints (95-5 tin-antimony)
Storm drain	All sizes	Cast iron hubless pipe (ASTM A 888 and CISPI 301); Fittings: No-hub coupling (CISPI 310), stainless steel shield and clamp assembly with elastomeric sealing sleeve (ASTM C-564)

END OF TABLE

END OF SECTION 15410

SECTION 15430 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes plumbing specialties for water distribution systems; storm drainage systems; and central vacuum cleaning systems.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME)

1. A112.6.3 Floor Drains
2. B31.9 Building Services Piping
3. B1.20.7 Hose Coupling Screw Threads

B. American Society of Sanitary Engineering (ASSE)

1. 1013 Reduced Pressure Principle Backflow Preventers

C. American Society for Testing Materials (ASTM)

1. A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
2. C564 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
3. D1248 Polyethylene Plastics Molding and Extrusion Materials

D. Cast Iron Soil Pipe Institute (CISPI)

E. National Fire Prevention Association (NFPA)

1. 70 National Electrical Code (NEC)

F. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Regulations for a Nationally Recognized Testing Laboratory (NRTL).

G. Plumbing & Drainage Institute (PDI)

1. WH - 201

H. Underwriters Laboratories (UL)

1. 1479 Standard for Safety Fire Tests of Through Penetration Firestops.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with following minimum working pressure ratings, except where otherwise indicated:

1. Cold Water Make-up Distribution Systems, Above Ground: 125 psig.
2. Storm Drainage Systems: 10 foot head of water.
3. Domestic Hot and Water Distribution System: 125 psig.
4. Sanitary Drainage System: 10 foot head of water.

1.4 SUBMITTALS

A. Submit product data including rated capacities of selected models and weights (shipping, installation, and operation). Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following plumbing specialty products:

1. Floor drains and open receptors.
2. Sleeve penetration systems.
3. Backflow Preventers.
4. Water Hammer Arrestors.
5. Automatic and Electronic Trap Primers.
6. Water Filters (Cartridge Type).
7. Vacuum cleaning valves.
8. Water Softener

B. Submit Shop Drawings to indicate plans, piping diagrams, electrical diagrams, calculations, accessories, and equipment details for approval prior to the delivery of materials.

C. Maintenance data for inclusion in Operating and Maintenance manuals for the following:

1. Backflow Preventers.
2. Automatic and Electronic Trap Primers.
3. Water Filters.
4. Water Softener.

1.5 QUALITY ASSURANCE

A. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

B. Listing and Labeling: Provide equipment that is listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

C. Design Concept: The Drawings indicate capacities, sizes, and dimensional requirements of system components. Components having equal performance characteristics that deviate from the indicated size and dimensions may be considered, provided deviations do not change the design concept or intended performance. The burden of proof for equality of products is on the Contractor.

D. Comply with requirements of EPA and State and Local Authorities having jurisdiction. Include recording of storage tanks and monitoring of tanks.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Known Acceptable Sources

1. Sleeve Penetration Systems:
   a. Proset Systems, Inc. or equal.
2. Water Softener:
   a. Culligan International

2.2 MISCELLANEOUS PIPING SPECIALTIES

A. Piping specialties such as escutcheons, dielectric fittings, sleeves, and sleeve seals are specified in Section 15050 "Basic Mechanical Materials and Methods."

2.3 FLOOR DRAINS

A. General: Size outlets as indicated on drawings.

B. Floor Drain (FD): Conforms to ASME A112.6.3, PVC body, cast iron frame and grate (heavy duty), weep holes, bottom outlet, and 1/2” trap primer connection.

2.4 SLEEVE PENETRATION SYSTEMS

A. Description: UL 1479, through-penetration firestop assembly consisting of sleeve and stack fitting with firestopping plug.

1. Sleeve: ASTM A53 Schedule 40, galvanized.

2.5 BACKFLOW PREVENTERS

A. Backflow preventers shall be manufactured and rated in accordance with ASSE Standard 1013.

B. Backflow preventers shall be reduced pressure principal type and shall be provided with shutoff valves on the inlet and outlet, strainer on the inlet, test cocks and a differential pressure relief valve located between two positive seating check valves.

2.6 WATER HAMMER ARRESTORS

A. Provide hydraulic shock absorbers in cold and hot water supply lines to each fixture branch or battery of fixtures, and at each automatic, solenoid-operated or quick-closing valve serving mechanical equipment.

B. Provide hydraulic water hammer arrestors that are precharged with air, completely sealed and operating free of casing.

C. All water hammer arrestors shall be rated and sized in accordance with PDI-WH-201.

2.7 AUTOMATIC AND ELECTRONIC TRAP PRIMERS

A. Provide differential type automatic trap primers and auxiliary inlet fitting for all floor drains.

B. Piping from automatic trap primers to traps shall be ½ inch type L copper with no fittings.

2.8 WATER FILTERS

A. Provide a cartridge type filter with a liquid flow rate of 5-10 GPM, 10 inch cartridge length.

B. Piping to filter shall be 3/4” Type L or K copper with gate valves for shut-offs and dielectric unions.

2.9 CENTRAL VACUUM SYSTEM

A. Verify the existing vacuum outlet location and condition. If necessary, relocate and replace valves.

B. Piping and fitting shall be Zinc coated tubing, 16 gage, complying with ASTM A513, Type 1, C-1010. Provide approved adhesive heat shrinkable sleeve joints. Known acceptable source: Spencer Turbine Company.

C. Match existing valve in appearance; size as required by design. Valve shall be two-inch forged brass valve body with a natural brush finish. The valve shall be 2-inch male thread-beveled edge designed for use with carpets. Known acceptable source: Spencer Turbine Company.

2.10 WATER SOFTENER

A. Provide a vertical pressure type water softener system complete with pressure vessel, softening resin, control valve, brine maker, controller and water meter. The water softener shall meet the following specifications.

1. Number of tanks: 2
2. Exchange capacity @ Salt Dosage Per Recharge: 13,760 gr @ 3.3 lb; 27,848 gr @ 9.3 lb; 32,939 gr @ 15 lb
3. GPM: 10.7 gpm @ 15 psi
4. Tank Size (Diameter x Height): 9” x 48”
5. Brine Tank (Diameter x Height): 16” x 43” (two each)
6. Electrical Requirements: 10’ cord and wall mount plug-in transformer (24V/60 Hz)
7. Electrical Power Consumption: 5 Watts min, 6 Watts max
8. Operating Pressure: 20-125 psi
9. Operating Temperature: 33-120 deg F

B. Known Acceptable Source: Culligan International (Soft-Minder Twin Plus 9”, Model SM-61)

PART 3 - EXECUTION

3.1 FLOOR DRAIN INSTALLATION

A. Install floor drains according to manufacturer's written instructions, in locations indicated.

B. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.

C. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

D. Position drains for easy accessibility and maintenance.

3.2 INSTALLATION OF BACKFLOW PREVENTERS

A. Install backflow preventers in accordance with the manufacturer’s recommendations.

3.3 INSTALLATION OF WATER HAMMER ARRESTORS

A. Install water hammer arrestors in accordance with the manufacturer’s recommendations.

B. Install water hammer arrestors where accessible and as indicated on the drawings. Provide access panels in accordance with IPC.

3.4 INSTALLATION OF AUTOMATIC TRAP PRIMERS

A. Install automatic trap primers in accordance with the manufacturer's recommendations and as indicated on the drawings.

3.5 INSTALLATION OF WATER FILTERS

A. Install water filters in accordance with the manufacturer's recommendations and as indicated on the Drawings.

3.6 INSTALLATION OF WATER SOFTENER

A. Install water softener in accordance with the manufacturer's recommendations and as indicated on the Drawings. A factory authorized service representative shall inspect completed installation to ensure that water softener is installed according to manufacturer's recommendations.

3.7 COMMISSIONING

A. Preparation: Perform the following checks before start-up:

1. Complete system checks.
2. Replace or repair damaged and defective specialties and accessories.
3. Demonstrate that there is clear space for servicing of all installations.

B. Before operating systems, perform these steps:

1. Close drain valves, hydrants, and hose bibbs.
2. Open valves to full open position.
3. Remove and clean strainers.
4. Verify drainage and vent piping are clear of obstructions. Flush with water until clear.

3.8 ADJUSTING

A. Adjust operation and correct deficiencies discovered during commissioning.

3.9 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from construction work.

B. Place plugs in ends of uncompleted piping at end of day or when work stops.

3.10 TRAINING

A. Prior to operation, provide two four hour sessions of operating training and trouble shooting to maintenance personnel. Each training session shall include a complete demonstration of the system; emergency procedure; system control panel operation; trouble procedures; and safety requirements. Submit training schedule and materials to COR for approval at least fourteen (14) days prior to start of training. Conduct the training with the manufacturer's qualified instructor. Equipment installers are not acceptable instructors.

END OF SECTION 15430

SECTION 15440 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes plumbing fixtures and trim, fittings, and accessories, appliances, appurtenances, equipment, and supports associated with plumbing fixtures.

1.2 REFERENCE STANDARDS

A. American National Standard Institutes (ANSI)

1. A112.19M Enameled cast iron plumbing fixtures.
2. A117 Providing accessibility and usability for physically handicapped people.

B. American Society of Mechanical Engineers (ASME)

1. A112.18.1M Plumbing fixture fittings.
2. A112.6.1M Supports for off - the floor plumbing fixture for public use.
3. A112.19.4M Porcelain enameled formed steel plumbing fixtures.

C. Air Conditioning and Refrigeration Institute (ARI)

1. 1020 Application and installation of drinking fountains and drinking water cooler.
2. 1010 Drinking fountains and self-contained mechanically refrigerated drinking water coolers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Known Acceptable Source:

1. Water Closets:

   a. Toto USA Inc.
   b. American Standard.
   c. Kohler Co.

2. Urinals:

   a. Toto USA Inc.
   b. American Standard.
   c. Kohler Co.

3. Lavatories:

   a. American Standard, Inc.
   b. Eljer.
   c. Kohler Co.

4. Service Sinks:

   a. American Standard, Inc.
   b. Kohler.
   c. Elkay Manufacturing Co.

5. Water Coolers:

   a. Elkay Manufacturing Co.

6. Toilet Seats:

   a. Toto USA Inc.
   b. American Standard.
   c. Kohler Co.

7. Flushometers:

   a. Sloan Valve Co.
   b. Zurn Industries, Inc.
   c. Toto USA Inc.

8. Faucets:

   a. Sloan.
   b. Zurn.
   c. Speakman.

2.2 PLUMBING FIXTURES, GENERAL

A. Provide plumbing fixtures and trim, fittings, other components, and supports as specified in "Plumbing Fixture Data Sheets" at the end of Part 3 of this Section.

2.3 FAUCETS

A. Faucets General: Unless otherwise specified, provide faucets that are cast brass with polished chrome-plated finish.

B. Lavatory Faucet: Coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.
   1. Available Products:
      a) Sloan; Optima Electronic Lavatory Faucet, EAF-200-P-ISM

2. Maximum Flow Rate: 2.2 gpm.
3. Body Material: Brass.
4. Finish: Polished chrome.
5. Mounting: Deck, single hole, exposed.
6. Handle(s): None.
7. Spout: 4-11/32" spout.
8. Drain: Chrome plated metal drain and trap.
9. Power: Plug-in type.
10. Other: Integral spout temperature mixer; 6 Volt DC Plug-in transformer, capacitor, daisy chain electrical cable to connect multiple electronic faucets to one plug-in transformer; ADA.

C. Service Sink Faucet, Type 1: ASME A112.18.1M, rough chrome finish, cast brass, with stops in shanks, and integral vacuum breaker, pail hook, and garden hose thread on spout.

2.4 FITTINGS, EXCEPT FAUCETS

A. Fittings General: Unless otherwise specified, provide fittings fabricated of brass, with a polished chrome plated finish.

B. Lavatory Traps, Type 1: Cast-brass, 1-1/4-inch NPS adjustable P-trap with cleanout, 17-gage tubular waste to wall, and wall flange.

C. Escutcheons: Polished chrome-plated, sheet steel wall flange with friction clips.

D. Provide fittings specified as part of a fixture description, in lieu of fitting requirements above.

2.5 FLUSHOMETERS

A. Provide ADA compliant, automatic flushometers compatible with fixtures, with features and of consumption indicated. Flushometers used in handicap stalls shall be selected so that pushbutton override is located and accessible on the wide side of the stall per ADA requirements.

B. Construction: Cast-brass body, brass or copper pipe or tubing inlet with wall flange and tailpiece with spud coupling for top spud, screwdriver check stop, vacuum breaker, and push button overide. Type shall be diaphragm operation except where other type is specified.

C. Finish: Exposed metal parts shall be polished chrome-plated, except components installed in a concealed location may be rough brass or unfinished.

D. Water Closet Flushometers, Type 1: Furnish with following features:

1. Sensor Flush (Active infrared).
2. Wheel handle stop.
3. Battery operated sensor and low battery flashing LED.
4. Furnish flushometers with factory-set or field-adjusted maximum water consumption per cycle:

a. Consumption: 1.6 gallons per flushing cycle.
b. Known Acceptable Source: Sloan, Model G2 Optima Plus 8111

E. Urinal Flushometers, Type 1: Furnish with following features:

1. Sensor flush (active infrared).
2. Battery operated sensor and low battery flashing LED.
3. Furnish flushometers with factory-set or field-adjusted maximum water consumption per cycle:

a. Consumption: 1.0 gallons per flushing cycle.
b. Known Acceptable Source: Sloan, Model G2 Optima Plus 8186-1.0

2.6 TOILET SEATS

A. General: Provide toilet seats compatible with water closets, and of type, color, and features indicated.

B. Toilet Seats, Type 1: Extra heavy-duty, commercial/industrial type, elongated, open front, solid plastic, with check hinge.

C. Known Acceptable Source: Toto USA Inc., Model SC534

2.7 PLUMBING FIXTURE SUPPORTS

A. Supports: ASME A112.6.1M, categories and types as required for wall-hanging fixtures specified, and wall reinforcement.

B. Support categories are:

1. Carriers: Supports for wall-hanging water closets and fixtures supported from wall construction. Water closet carriers shall have an additional face-plate and coupling when used for wide pipe spaces. Provide tiling frame or setting gage with carriers for wall-hanging water closets.
2. Chair Carriers, Heavy Duty: Supports with rectangular steel uprights for wall-hanging fixtures.
3. Reinforcement: 2-inch by 4-inch wood blocking between studs or 1/4-inch by 6-inch steel plates attached to studs, in wall construction, to secure floor-mounted and special fixtures to wall.

C. Support Types: Provide support of category specified, of type having features required to match fixture.

D. Provide supports specified as part of fixture description, in lieu of category and type requirements above.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for potable cold water and hot water supplies and soil, waste, and vent piping systems to verify actual locations of piping connections prior to installing fixtures.

B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Install plumbing fixtures and specified components, in accordance with designations and locations indicated on Drawings.

B. Install supports for plumbing fixtures in accordance with categories indicated, and of type required:

1. Carriers for following fixtures:

a. Wall-hanging water closets.
b. Wall-hanging fixtures supported from wall construction.

2. Chair carriers for the following fixtures:

a. Wall-hanging urinals.
b. Wall-hanging drinking fountains and electric water coolers.

3. Reinforcement for the following fixtures:

a. Recessed, box-mounted electric water coolers.

3.3 INSTALLATION OF PLUMBING FIXTURES

A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers' written installation instructions, roughing-in drawings, and referenced standards.

B. Install wall-hanging, back-outlet water closets with support manufacturer's tiling frame or setting gage.

C. Install wall-hanging, back-outlet urinals with gasket seals.

D. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.

E. Fasten wall-mounted fittings to reinforcement built into walls.

F. Fasten counter-mounting-type plumbing fixtures to casework.

G. Secure supplies behind wall or within wall pipe space, providing rigid installation.

H. Install stop valve in an accessible location in each water supply to each fixture.

I. Install trap on fixture outlet except for fixtures having integral trap.

J. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons where required to conceal protruding pipe fittings.

K. Seal fixtures to walls, floors, and counters using a sanitary-type, one-part, mildew-resistant, silicone sealant in accordance with sealing requirements specified in Section 07920, "Joint Sealants." Match sealant color to fixture color.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other sections of Division 15. The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections of Division 15.
2. Install piping connections indicated between appliances and equipment specified in other sections, direct connected to plumbing piping systems.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.6 ADJUSTING AND CLEANING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at electric water coolers, and faucets and flushometers having controls, to provide proper flow and stream.

C. Replace washers of leaking and dripping faucets and stops.

D. Clean fixtures, fittings, and spout and drain strainers with manufacturers' recommended cleaning methods and materials.

E. Review the data in Operating and Maintenance Manuals.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of fixtures for temporary facilities, except when approved in writing by the COR.

3.8 FIXTURE SCHEDULE

A. Provide plumbing fixtures as scheduled on the following "Data Sheets."

3.9 WATER CLOSET DATA SHEET

A. Water Closet, Type P-1A:

Type: Siphon jet, elongated, ADA, top spud inlet.

Material: Vitreous china.

Mounting and Outlet: Wall hanging, back outlet.

Rim Height: Handicap use: 18 inches.

Consumption: 1.6 gallons.

Color: White.

Fittings and Accessories: Provide the following compatible components:

Flushometer: As specified in paragraph 2.5.

Toilet Seat: As specified in paragraph 2.6.

Known Acceptable Source: Toto USA Inc., Model CT708

B. Water Closet, Type P-1:

Type: Siphon jet, elongated, top spud inlet.

Material: Vitreous china.

Mounting and Outlet: Wall hanging, back outlet.

Rim Height: Normal use: 14 to 15 inches.

Consumption: 1.6 gallons.

Color: White.

Fittings and Accessories: Provide the following compatible components:

Flushometer: As specified in paragraph 2.5.

Toilet Seat: As specified in paragraph 2.6.

Known Acceptable Source: Toto USA Inc., Model CT708

3.10 URINAL DATA SHEET

A. Urinal, Type P -2:

Material: Vitreous china.

Urinal Type: Low consumption 1.0 gallon extended side for privacy, flushing rim, top spud inlet.

Mounting and Outlet: Wall hanging, back outlet.

Consumption: 1.0 gallons.

Color: White.

Fittings and Accessories: Provide the following compatible components:

Flushometer: As specified in paragraph 2.5.

Trap: Internal trap.

Known Acceptable Source: Toto USA Inc., Model UT447

B. Urinal, Type P -2A:

Material: Vitreous china.

Urinal Type: Low consumption 1.0 gallon extended side for privacy, flushing rim, top spud inlet.

Mounting and Outlet: Wall hanging, back outlet.

Consumption: 1.0 gallons.

Color: White.

Fittings and Accessories: Provide the following compatible components:

Flushometer: As specified in paragraph 2.5.

Trap: Internal trap.

Known Acceptable Source: Toto USA Inc., Model UT447

3. 11 LAVATORY DATA SHEET

A. Lavatories, Type P-2 and P-2A:

Material: Vitreous china.

Lavatory Type: Self-rimming, countertop (mounted type).

Bowl Dimensions: 16" wide, 5-5/8" deep and 10" front to back.

Nominal Dimensions: 20-3/8" wide, 7" deep and 17-3/8" front to back.

Mounting: Countertop mounting.

Color: White.

Fittings and Accessories: Provide the following compatible components:

Supplies: Same as Part 2 of Section Text

Supply Flow Control Fitting Rate: 0.5 gallons per minute.

Drain: Front overflow drain.

Trap: 1-1/4" trap.

Known Acceptable Source: American Standard, Aqualyn Countertop Sink, Model 0475.047

3.12 SERVICE SINK DATA SHEET

A. Service Sink, Type P-4: As specified.

Applicable Standards: ANSI Standard A112.19.1M

Material: Enameled cast iron.

Dimensions: 28" x 28".

Fittings and Accessories: Provide the following compatible components:

Faucet: Service faucet, wall mounted with vacuum breaker

Strainer: Strainer and socket.

Rim Guard: Removable vinyl-coated rim guard.

Hose and Bracket: 30".

Trap: 3" trap.

Faucet Support: Supply with faucet.

3.13 WATER COOLER DATA SHEET

A. Water Coolers, Type EWC: As specified.

Applicable Standards: ARI 1010, NSF/ANSI 61.

Water Cooler Type: Two station wall-mounted, ADA accessible, water cooler with filter.

Capacity: 8 gallons per hour of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.

Cabinet Material: Bi-level with two attached cabinets, enameled steel with stainless steel top.

Bubbler: One, with automatic stream regulator, located on each cabinet deck.

Control: Push bars on front and sides.

Supply: 3/8 OD copper with ball valve.
Drains: 1-1/2" nominal waste and trap (furnished and installed by mechanical contractor).

Cooling System: Electric, with hermetically sealed, reciprocating type, compressor; cooling coil; air-cooled condensing unit; corrosion-resistant tubing; HFC-134a refrigerant; and adjustable thermostat.

Electrical: 120V, 60 Hz, 370 W, FLA 4 amps. Equipped with electric cord and three prong molded rubber plug.

Mounting: As per manufacturer's recommendations.

Known Acceptable Source: Elkay Manufacturing Co., Model LZSTL8C with WaterSentry VII Filter System.

END OF SECTION 15440

SECTION 15810 - HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes humidifiers for installation in HVAC equipment, ducts and plenums.

1.2 REFERENCE STANDARDS

A. Air Conditioning and Refrigeration Institute (ARI)

1. 620 - Self Contained Humidifiers.
2. 640 - Commercial and Industrial Humidifier.

B. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code (NEC).

C. Occupational Safety and Health Administration

1. 29 CFR 1910.7 - Definitions and Regulations for a Nationally Recognized Testing Laboratory (NRTL).

1.3 SUBMITTALS

A. Product data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories.

B. Shop drawings detailing fabrication and installation of humidifiers and dispersion tubes, including plans, elevations, sections, details of components, and attachments to other units of Work. Detail connections to water piping.

C. Coordination drawings drawn accurately to scale and showing humidifiers and adjacent equipment. Submit with shop drawings. Show support locations, type of support, and weight on support.

D. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed wiring and field-installed wiring.

E. Maintenance data for humidifiers for inclusion in Operation and Maintenance Manual specified in Division 1. Include detailed manufacturer's instructions on startup, shutdown, troubleshooting, preventive maintenance, and servicing. Include parts list and list of accessories.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firm experienced in manufacturing humidifiers similar to those indicated for this Project and that have a record of successful in-service performance.

B. ARI Compliance: Test and rate humidifiers according to ARI 620.

C. Comply with NFPA 70 for components and installation.

D. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the NEC, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

E. Coordinate layout and installation of humidifiers with duct and air handlers.

1. Revise locations and elevations as required to suit field conditions and to assure proper humidifier operation, and as approved by the COR.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle humidifiers according to manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Known Acceptable Source: Subject to compliance with requirements, provide products by the following:

1. Self-Contained Humidifier:

a. Dri-Steem Humidifier Co.

2.2 SELF-CONTAINED STEAM GENERATOR

A. Furnish an electronic electrode type steam generator, designed to inject steam into the humidifier section. Incorporate an automatic control system to monitor the contained water conductivity, and control the fill and drain rates to maximize container life and minimize energy consumption. The automatic control system shall allow and compensate for varying entering water conditions without having to change electrode spacing. The unit shall have a minimum capacity as indicated.

B. The humidifier cabinet shall be 14 gage steel with baked on enamel finish. Cabinet shall have a hinged and lockable access door to the electrical compartment. Provide an additional screw

mounted cover to further isolate the line voltage components, and separate removable and lockable access door to plumbing compartment. The cabinet shall house the vaporizing chamber and related appurtenances and the microprocessor control system. The microprocessor control system shall provide monitoring and alarms for unit malfunctions including high and low water. The unit shall be controlled by a control signal compatible with the DDCP system (4-20 mA signal), and shall provide an unit maintenance/failure signal to the DDCP. Pipe the steam to ductwork through rigid steam pipe and dispense into airstream with factory supplied steam distributors. Pipe condensate return to condensate drain line. Fabricate and install a sheet metal drain pan 2 inches high under humidifier cabinet. Pipe drain to the nearest standing drain.

C. Water Supply: Provide air gap in fill line to prevent backflow into supply line.

D. Humidification: Humidifier shall be an electrical evaporative UL listed humidifier, designed to operate with potable untreated utility water and shall be provided with the following features: vaporizing chamber and cover shall be stainless steel with helic-arc welded seams, the immersion heater shall be "incoloy" alloy sheathed resistance type heater maximum 88 watts per square inch and shall be mounted on the vaporizing chamber's removable cover. The electronic water level control shall provide automatic refill, low water cut-off and periodic drain down cycles. System shall consist of: A water level sensing unit, a solenoid operated fill valve mounted on the vaporizing chamber cover, electronic level control board and timer drain down control board mounted on an electrical subpanel and motor driven brass bodied drain valve mounted on the vaporizing chamber. Unit shall be provided with surface skimmer for mineral removal, control system with step down transformer, vapor hose kit with stainless steel hose clamps, time proportioning modulating control for operation range of 20% to 80% R.H. Disposable cylinder type electronic humidifier shall not be acceptable.

E. Humidifier shall discharge pure steam, with no mineral dust carry over, through factory built steam distributors mounted in the airstream. Distributors shall be "Ultra-Sorb" of type suitable for application with the specified humidifier and a length suitable for insertion in duct as indicated. Distributors shall incorporate a condensate separator and return leg to remove condensate from the distributor. The steam shall be absorbed in the air stream in less than two feet, at 90 percent relative humidity (RH), from the distributor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts and air handlers to receive humidifiers for compliance with requirements for installation tolerances and other conditions affecting performance of humidifiers. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install humidifiers as indicated, according to manufacturer's written instructions and ARI 640.

B. Allow clearance for maintenance and service.

C. Seal humidifier dispersion tube ductwork penetrations.

D. Connect humidifier and components as indicated and instructed by manufacturer.

E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical Installer. Coordinate requirements with DDCP installer.

F. Ground electrically operated humidifiers and components.

3.3 COMMISSIONING

A. Startup Services: Provide the services of a factory-authorized service representative to provide startup service.

B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements of Division 16 Sections. Do not proceed with startup until wiring installation is acceptable to equipment Installer.

C. Start humidifiers according to manufacturer's instructions.

D. Operate and adjust controls and safeties.

E. Set Humidity level: Verify relative humidity and coordinate control requirements with DDCP installer.

3.4 CLEANING

A. Clean factory finished surfaces. Repair marred or scratched surfaces with manufacturer's touchup paint.

3.5 DEMONSTRATION

A. Demonstrate the following:

1. Unit automatic operation.
2. Steam production.
3. Condensate drainage.

B. Review data in the operation and maintenance manuals. Refer to Division 1.

3.6 IDENTIFICATION

A. Provide identification and tags as required in Section 15190, “Mechanical Identification.”

3.7 TRAINING

A. Prior to operation, provide two two-hour sessions of operating training and trouble shooting to maintenance personnel. Each training session shall include the following:

1. Complete demonstration of the system.
2. Emergency procedures.
3. System control panel operation.
4. Trouble shooting procedures.
5. Safety requirements.

B. Submit training schedule and materials to COR for approval at least fourteen (14) days prior to start of training.

C. Conduct the training with the manufacturer's qualified instructor. Equipment installers are not acceptable instructors.

END OF SECTION 15810

SECTION 15850 - AIR HANDLING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of air-handling units:

1. Power ventilators: roof-mounted exhausters.
2. Centrifugal blowers.
3. Outside air intake hoods.

B. Products furnished but not installed under this Section include roof curbs for roof-mounted exhaust fans.

1.2 REFERENCE STANDARDS

A. American Bearing Manufacturers Association (ABMA)

1. 9 Load Ratings and Fatigue Life for Ball Bearings.
2. 11 Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association (AMCA)

1. 210 Laboratory Methods of Testing Fans for Ratings.
2. 300 Test Code for Sound Rating.
3. 301 Method for Calculating Fan Sound Ratings from Laboratory Test Data.

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

1. 51 Laboratory Methods of Testing Fans for Rating.

D. National Fire Protection Agency (NFPA)

1. 70 National Electrical Code (NFPA).

E. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Regulations for a Nationally Recognized Testing Laboratory (NRTL).

1.3 SUBMITTALS

A. Product data for selected models, including specialties, accessories, and the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound power ratings.
   3. Motor ratings and electrical characteristics plus motor and fan accessories.
   4. Materials thickness' and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.

B. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

C. Shop drawings, in accordance with Section 15050, "Basic Mechanical Materials and Methods" for roof penetration requirements, and reflected ceiling plans drawn accurately to scale and coordinating penetrations and units. Show the following:

   1. Roof framing and support members relative to fan penetrations.
   2. Ceiling suspension members.
   3. Method of attaching hangers to building structure.

D. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field- installed wiring.

E. Product certificates, signed by manufacturers of air-handling units, certifying that their products comply with specified requirements.

F. Maintenance data for inclusion in Operating and Maintenance Manual.

1.4 QUALITY ASSURANCE

A. UL Compliance: Fans and components shall be UL listed and labeled.

B. NRTL and NEMA Compliance: Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Lift and support units with the manufacturer's designated lifting or supporting points.

B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating.

D. Provide covered shelter for the equipment and cover each with polyethylene cover separately.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the installation of roof curbs, equipment supports, and roof penetrations specified in Section 07720, "Roof Accessories".

B. Coordinate the size and location of structural steel support members.

1.7 EXTRA MATERIALS

A. Furnish one additional complete set of belts for each belt-driven fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Known Acceptable Sources:

1. Centrifugal Roof Ventilators:

a. Cook (Loren) Co.
b. Greenheck Fan Corp.

2. Centrifugal Blowers:

a. Cook (Loren) Co.
b. Greenheck Fan Corp.

3. Outside Air Intake Hood:

a Cook (Loren) Co.
b. Penn Ventilator Co. Inc.

2.2 SOURCE QUALITY CONTROL

A. Testing Requirements: The following factory tests are required:

1. Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating." Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

2.3 FANS, GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.65.

D. Belts: Oil-resistant, non-sparking, and nonstatic.

E. Motors and Fan Wheel Pulleys: Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

F. Shaft Bearings: Provide type indicated, having a median life "Rating Life" (ABMA L(50)) of 200,000, calculated in accordance with ABMA Standard 9 for ball bearings and ABMA Standard 11 for roller bearings.

G. Factory Finish: The following finishes are required:

1. Sheet Metal Parts: Prime coating prior to final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.

2.4 CENTRIFUGAL ROOF VENTILATORS

A. General Description: Belt-driven, centrifugal consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base with venturi inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
4. Fan and motor isolated from exhaust air stream.

E. Accessories: The following items are required as indicated:

1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
2. Bird Screens: Removable 1/2 inch mesh, stainless steel.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base, factory set to close when fan stops.
4. Roof Curbs: Prefabricated, heavy-gage, galvanized steel; mitered and welded corners; 2-inch-thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks: and two inch wood nailer. Size as required to suit roof opening and fan base.

2.5 CENTRIFUGAL BLOWER EF-1A AND EF-1B

A. General Description: Centrifugal consisting of housing, wheel, fan, shaft, bearings, motor and disconnect switch, and accessories. EF-1A shall have side inlet and top angular upward discharge as indicated on contract drawings. EF-1B shall be square inline as indicated on drawing contract drawings. EF-1A shall be belt drive and EF-1B direct drive.

B. Housing: 18 gage, bolted construction with integral duct collars. Three sides shall have bolted access doors with closed cell neoprene gaskets.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Direct Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
2. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
3. Motor isolated from exhaust air stream.

E. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
4. Fan and motor isolated from exhaust air stream.

F. Accessories: The following items are required as indicated:

1. Disconnect Switch: Nonfusible type, with thermal overload protection.
2. Universal mounting leg for installation.

2.6 OUTSIDE AIR INTAKE HOODS

A. General: Provide standard prefabricated outside air intake hoods of type and size indicated, modified as necessary to comply with indicated requirements and for a complete installation.

B. Housing: Provide aluminum waterproof housings with hinged hoods designed for air intake. Continuous welded vertical seams with lock formed seams on hood ends. Stress and slope hoods for drainage. Provide rectangular base to suit roof curb.

C. Bird Screen: Provide removable bird screens, 1/2 inch mesh, 16 gage aluminum or brass wire, and removable aluminum insect screen. Install bird screens around the bottom perimeter of the hoods and install insect screen in the protected area atop the airshaft.

D. Accessories: The following item is required as indicated:

1. Roof curbs: Prefabricated, heavy-gage, galvanized steel; mitered and welded corners; 2-inch-thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks: and two inch wood nailer. Size as required to suit roof opening and fan base.

2.7 MOTORS

A. See requirements in Section 15170, “Motors.”

B. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fans.

B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install fans and intake hoods level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated. Vibration control devices are specified in Section 15070 "Mechanical Vibration and Seismic Controls".

1. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.

a. Installation of roof curbs is specified in Section 07720, "Roof Accessories."

3.3 CONNECTIONS

A. Duct installations and connections are specified in other Division 15 sections. Make final duct connections with flexible connections.

B. Electrical Connections: The following requirements apply:

1. Electrical power wiring is specified in Section 16120, "Wires and Cables".
2. Temperature control wiring and interlock wiring are specified in Section 15975, "Control Systems - Electronic and Direct Digital Controls."
3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Inspection: Arrange and pay for a factory- authorized service representative to perform the following:

1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
2. Prepare a written report on findings and recommended corrective actions.

3.5 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

3.6 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.
2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

   a. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

C. Shut unit down and reconnect automatic temperature control operators.

D. Refer to Section 15990, "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

3.7 IDENTIFICATION

A. Provide identification and tags as required in Section 15190, “Mechanical Identification.”

3.8 TRAINING

A. Prior to operation, provide two (2) two-hour sessions of operating training and trouble shooting to maintenance personnel. Each training session shall include the following:

1. Complete demonstration of the system
2. Emergency procedures
3. System control panel operation
4. Trouble shooting procedures
5. Safety requirements

B. Submit training schedule and materials to COR for approval at least fourteen (14) days prior to start of training.

C. Conduct the training with the manufacturer's qualified instructor. Equipment installers are not acceptable instructors.

END OF SECTION 15850

SECTION 15854 - CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes constant-volume, modular air-handling units with coils for indoor installations.

B. Related Sections include the following:

1. Division 15 Section "Motors" for motors used in modular indoor air-handling units specified in this Section.

1.2 REFERENCE STANDARDS

A. American Bearing Manufacturers Association (ABMA)

1. 9: Load ratings and fatigue life for ball bearings.

B. Air Movement and Control Association (AMCA)

1. 210: Laboratory method of testing fans for rating.
2. 300: Reverberant Room method for Sound testing fans.
3. 301: Methods for calculating fan sounds.

C. American Society for Testing and Materials (ASTM)

1. A36: Carbon structural steel.
2. C150: Portland cement.

D. National Electrical Manufacturers Association (NEMA)

1. MG1: Motors and generators.

E. Steel Structures Painting Council (SSPC)

1. SP2: Surface preparation hand tool cleaning.
2. SP3: Surface preparation power tool cleaning.

F. Air Conditioning and Refrigeration Institute (ARI)

1. 410: Forced-Circulation Air-Cooling and Air-Heating Coils.

2. 430: Central station air handling units.

G. National Fire Protection Association (NFPA)

1. 70: National Electrical Code (NEC).
2. 90A: Installation of air conditioning and ventilating systems.

H. Occupational Safety and Health Administration (OSHA)

1. 29CFR 1910.7: Definitions and Regulations for a Nationally Recognized Testing Laboratory (NRTL).

1.3 SUBMITTALS

A. Prepare submittal data in accordance with procedures of Division 1 Section, “Submittals.”

B. Product Data: For each type of modular indoor and outdoor air-handling units indicated. Include the following:

1. Certified fan-performance curves with system operating conditions indicated.
2. Certified fan-sound power ratings.
3. Certified coil-performance ratings with system operating conditions indicated.
4. Motor ratings, electrical characteristics, and motor and fan accessories.
5. Material gages and finishes.
6. Filters with performance characteristics.
7. Dampers, including housings and linkages.

C. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
3. Wiring Diagrams: Power, signal, and control wiring. Clearly differentiate between manufacturer-installed and field-installed wiring.
4. Drawing Scale: ½” = 1’-0”

D. Coordination Drawings: Submit with Shop Drawings at a scale of ½” = 1’-0”. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

E. Manufacturer Seismic Qualification Certification: Submit certification that modular indoor air-handling units, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." 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.

F. Field Quality-Control Test Reports: From manufacturer.

G. Prepare and distribute operations and maintenance data as specified in Division 1 Section, “Operation and Maintenance Manual Data.”

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain modular indoor and outdoor air-handling units through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated.

C. 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.

D. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

E. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

F. Comply with NFPA 70.

G. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit as a factory-assembled module with protective crating and covering. Provide covered shelter for storage with polyethylene covering for each AHU.

B. Lift and support units with manufacturers designated lifting or supporting points.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

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. Filters: Five sets (pre-filter and main filter) for each modular indoor air-handling unit.
2. Fan Belts: Two sets for each modular indoor air-handling unit fan.
3. Gaskets: Two sets for each access door.
4. Fan Bearings: Two sets for each fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Source: Subject to compliance with requirements, the manufacturers offering products that may be incorporated into the Work shall be limited to:

1. McQuay® International; Vision™ Air Handler (AHU-12 & 13).

Contact Lon Haberlach from Norby Company at 425-828-6636 for details.

2.2 MANUFACTURED UNITS

A. Modular indoor air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, and accessories. Provide external vibration isolation and external seismic protection only. The mechanical contractor shall coordinate with vibration and seismic engineers for the design of the external vibration isolation and external seismic protection of the AHU. Any on-site re-assembly of AHU's shall be accomplished in the presence of the manufacturer's representative to ensure the warranties are not void. Return air/outdoor air mixing box shall be field-fabricated by the mechanical contractor.

2.3 CABINET

1. Materials: The unit shall be constructed as a complete frame with removable panels. Removal of side panels shall not affect the structural integrity of the unit. The casing shall be able to withstand up to 5 in. wg. Positive or 5 in. wg. negative static pressure. Neoprene bulb-type gasketing shall be provided where modules join to prevent air leakage.

   A. Structural Support: G90 galvanized steel, 0.1084 inch (12 gage) thick.

   B. Base Rail Height: 6 inches.

   C. Outside Casing: G90 galvanized steel, 0.0516 inch (18 gage) thick with pre-painted baked enamel finish.

   D. Inside Casing: G90 Galvanized steel, 20 gage thick.

   E. Floor Plate: G90 galvanized steel, 16 gage.

B. Cabinet Insulation: Comply with NFPA 90A.

1. Materials: Injected foam insulation
2. Thickness: Minimum 2 inches thick, uncompressed with minimum 3 pound per cubic foot density.
3. Thermal Resistance (R-Value): 13 ft^2 * h * deg F / (BTU)
4. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
5. Location and Application: Injected in thermal broke double-wall assembly.

C. Access Panels and Doors: Access doors shall be constructed with a double-wall, solid, galvanized-steel interior panel and a solid, galvanized-steel exterior panel with injected foam insulation. Gasketing shall be provided around the full perimeter of the doors to prevent air leakage. Surface-mounted handles shall be provided to allow quick access to the interior of the module and to prevent through-cabinet penetrations that could cause air leakage. Access doors shall be hinged and removable for quick, easy access. Access doors shall be of the largest size available from the AHU manufacturer and shall be installed on both sides of the unit to allow access to all maintenance items. Doors shall be provided for all maintenance functions including, but not limited to, bearing service, etc..

1. Fan Section: Doors.
2. Coil Section: Doors.
3. Damper Section: Doors.
4. Filter Section: Doors.
5. Mixing Box Section: Doors

D. Condensate Drain Pans: Formed sections of 304 stainless-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) when units are operating at maximum catalogued face velocity across cooling coil. Drain pan shall be insulated underneath with 2” thick insulation. Drain pan shall be treated with biocide to resist microbial growth and mold.

1. Drain Connections: Both ends of pan.
2. Pan-Top Surface Coating: Anti-microbial coating.
3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.

2.4 FAN SECTION

A. Fan-Section Construction: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan rigidly without vibration isolation. Internal vibration isolators are not acceptable.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Performance Class: AMCA 99-2408, Class II
3. Horizontal Flanged Split Housing: Bolted construction.
4. Plug Fans: With steel cabinet. Fabricate without fan scroll and volute housing.

C. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.

D. Airfoil-Fan Wheels: DWDI Steel construction with smooth-curved inlet flange, heavy back-plate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange. Airfoil blades shall be double thickness design and shall be painted with zinc chromate primer and enamel paint.

E. Plenum fan sections shall have one single width single inlet (SWSI) airfoil fan wheel. Airfoil blades shall be double thickness design and shall be painted with zinc chromate primer and enamel paint.

F. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Rating Life: ABMA 9 or ABMA 11 minimum average life (L-50) of 200,000 hours.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
2. Motor Pulleys: Adjustable pitch for use with 15-hp motors and smaller; fixed pitch for use with motors larger than 20 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; matched for multiple belt drives.
4. Belt Guards: Fabricate to OSHA/SMACNA requirements; 0.1046-inch- thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent; prime coated.
5. Motor Mount: Adjustable for belt tensioning.

I. Vibration Control: Externally mounted combination vibration isolation and seismic bracing per Division 15 Section “Mechanical Vibration and Seismic Controls.”

J. Seismic rating: AHU assemblies shall be rated for a Seismic Design Category determined by a licensed professional engineer in accordance with Division 15 Section “Mechanical Vibration and Seismic Controls.”

K. Fan-Section Source Quality Control:

1. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

2.5 MOTORS

A. General: Refer to Division 15 Section "Motors" for general requirements. AHU motor shall be VFD compatible.

B. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.

C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.

D. Efficiency: Premium efficient motors according to IEEE 112, Test Method B unless noted otherwise in Division 15 Section “Motors.

E. Nameplate: Indicate ratings, characteristics, construction, special features, and full identification of manufacturer.

F. Starters, Disconnect Switches, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16 Sections.

2.6 COILS

A. Coil Sections: Common or individual, insulated, galvanized-steel casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils. AHU manufacturer shall select coil section with adequate space for freezestats and temperature sensors to be installed.

B. Water Coils: Continuous circuit coil fabricated according to ARI 410.
1. Coil Connections: Threaded, on same end, with connection size to be determined by manufacturer based upon the most efficient coil circuiting.
2. Tubes: Minimum 5/8-inch OD seamless copper tube, minimum 0.020 inch tube wall thickness.
3. Fins: Aluminum with maximum of 12 fins per inch, minimum thickness of 0.0075 inches.
4. Fin and Tube Joint: Mechanical bond.
5. Headers: Seamless copper tubing.
6. Frames: Galvanized-steel channel frame to rigidly support coil across full face, pitched to allow drainage.
7. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.

   a. Working-Pressure Ratings: 200 psig, 220 deg F.

8. Source Quality Control: Factory test to 300 psig.

2.7 FIELD FABRICATED SECTIONS

A. Galvanized sheet steel with G60 coating. Provide 2-inch duct liner. Refer to 15891 “Metal Ductwork” for construction standards and duct liner specification.

2.8 DAMPERS

A. General: Control Dampers and Damper Operators are specified in Division 15 Section "Electronic And Direct Digital Controls." Damper actuators shall be provided and installed by the Controls contractor.

B. Mixing Dampers: AHU dampers shall be provided and installed by the Controls Contractor. Damper actuators shall be provided and installed by the Controls contractor.

2.9 FILTER SECTION

A. Filters: Comply with NFPA 90A. Refer to Division 15 Section “Air Filters” for requirements.

B. Filter Section: Provide filter holding frames arranged for flat orientation, with hinged side access doors on both sides of unit and side access slide rails. Filters shall be removable from one side.

2.10 SMOKE DETECTION SENSOR

A. AHU-12 and AHU-13 shall be provided with smoke detection sensors from the fire alarm contractor. The smoke detection sensors shall be installed in the locations shown on the project drawings. The detectors shall be wired to the existing fire alarm control panel by the fire alarm contractor. Smoke detectors shall be hard-wired interlocked with the AHU fan.

2.11 MIXING BOX

A. Mixing box shall be custom built on-site by the sheet metal contractor with 18 gauge galvanized steel sheet metal in accordance with specification section 15891. Mixing box shall be insulated with 2" thick duct liner per specification section 15891. Seams shall be sealed air tight with duct sealant. Mixing box shall include insulated, hinged access doors on both sides. The mechanical contractor shall submit shop drawings of the mixing box to the Resident Engineer for approval.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install air-handling units level and plumb, according to manufacturer's written instructions.

B. Any on-site re-assembly of AHU’s shall be accomplished in the presence of the manufacturer’s representative to ensure the warranties are not void.

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Concrete Bases: Install units on concrete bases. See structural drawings for concrete base details.

E. Install modular indoor air-handling units with the following vibration and seismic-control devices. Vibration and seismic-control devices are specified in Division 15 Sections "Mechanical Seismic Protection" and "Vibration Control."

1. Concrete Base-Mounted Units: Support on concrete bases using restrained spring isolators (provided by others). Restrained spring isolators shall be designed and selected by seismic and vibration specialist, licensed as a professional engineer.

F. The air handlers DDC controls shall be integrated into the existing Johnson Controls DDC system. The local Johnson Controls representative shall perform all controls work on the new air handlers (see Division 15 specification, “Electronic and Direct Digital Controls”).

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to modular indoor and outdoor air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, Type L copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping." Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.

F. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

G. Electrical: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.

1. Temperature control wiring and interlock wiring is specified in Section 15975,"Electronic and Direct Digital Controls."

H. Ground equipment according to Division 16 Section "Grounding."

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. Install fabric type flexible duct connectors specified in mechanical section “Duct Accessories” to isolate AHU from main ductwork.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Final Checks before Startup: Perform the following:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set face-and-bypass dampers to full face flow.
7. Set outside- and return-air mixing dampers to minimum outside-air setting.
8. Comb coil fins for parallel orientation.
9. Install clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for modular indoor air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys and belts as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for modular indoor air-handling system testing, adjusting, and balancing.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

3.7 CLEANING

A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

3.8 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain modular indoor air-handling units. Provide three four hour sessions of operating training. Each training session shall include the following

1. Complete demonstration of the system.
2. Emergency procedures.
3. Operation of system controls.
4. Troubleshooting procedures
5. Safety requirements.

B. Conduct the training with instructors trained and approved by the manufacturer. Equipment installers are not acceptable instructors.

C. Provide training in accordance with this section and Division 1 Section, “Demonstration and Training.”

END OF SECTION

SECTION 15886 - AIR FILTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of air filters and accessories:

1. Replaceable (throwaway) panel filters.
2. Extended-surface, disposable-panel filters.
3. Filter frames.

1.2 REFERENCE STANDARDS

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

1. 52 Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

B. Air-Conditioning and Refrigeration Institute (ARI)

1. 850 Commercial and Industrial Air Filter Equipment.

C. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC).
2. 90A Installation of Air Conditioning and Ventilating Systems.
3. 90B Installation of Warm Air Heating and Air Conditioning Systems.

D. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL).

1.3 DEFINITIONS

A. Efficiency: As measured by the Dust Spot Method on Atmospheric Air, per ASHRAE Test Standard 52, unless otherwise noted.

B. Arrestance: per ASHRAE Test Standard 52.

C. Dust Holding Capacity: per ASHRAE Test Standard 52.

1.4 SUBMITTALS

A. Product data including dimensions, weights, required clearances and access, flow capacity including initial and final pressure drop at rated air flow, efficiency and test method, and fire classification.

B. Shop drawings showing assembly of filter racks, dimensions, materials, and methods of assembly of components.

1. Include setting drawings, templates, and requirements for installing anchor bolts and other anchorage's to other units of Work.
2. Show dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

C. Maintenance data for each type of filter and rack required for inclusion in Operating and Maintenance Manual.

1.5 QUALITY ASSURANCE

A. Fire Performance Characteristics: Provide filters identical with those tested for the fire performance characteristics indicated. Identify with appropriate markings of applicable testing and inspecting agency.

B. Electrical Component Standard: Provide components that comply with the NEC.

C. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B pertaining to installing air filters.

D. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing and rating air filter units.

E. ARI Compliance: Comply with provisions of ARI Standard 850 pertaining to testing and performance of air filter units.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Lift and support factory-assembled units only at designated lifting or supporting points, as indicated on shop drawings. Deliver with protective crating and covering.

1.7 EXTRA MATERIALS

A. Provide five complete extra sets of Type A and B filters for each air handling system. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from COR that new filters have been installed.

B. Provide 3 extra filter gages complete with pressure tips, tubing, gage connections and mounting brackets. Provide written instructions for mounting gages.

PART 2 - PRODUCTS

2.1 AIR FILTERS, GENERAL

A. Air by-pass: Construct filters so as to prevent the passage of unfiltered air. Provide felt, rubber, or neoprene gaskets, or other permanent means, to prevent air bypass between filter frames and supporting members (housing and casings).

B. Finish: Protect steel filter parts against corrosion with a baked on enamel, epoxy resin, polyvinyl coating, zinc-coating, cadmium plating, two coats of oil paint, two coats of lacquer, or coat with alkyd paint after phosphate cleaning.

C. Identification: Provide each filter with an identification device mounted in a location where it will be visible after installation; show model number and all other data necessary for ordering renewal media.

D. Supports: If required, provide supports (screen, grid, or frame type) for filters adequate to position the media for uniform air distribution without tearing, and to prevent excessive motion and deflection under varying air flow conditions.

E. Replacement Filters: Provide all replacement filters and filter media that are the same as specified for the applicable type filter.

F. All outside air and recirculated air shall be filtered, except as noted. Filters shall be Underwriters Laboratories, Inc. (UL) listed filters. Air flow shall not exceed rated capacity at specified efficiency. Performance shall be tested and certified per ASHRAE Standard 52.

2.2 MANUFACTURERS

A. Known Acceptable Source:

1. Particulate Air Filters: Replaceable Panel (Throwaway) Type A:

   a. American Air Filter Co., Inc.
   b. Farr Co.
   c. Cambridge Filter Co.

2. Particulate Air Filter: Extended Surface, Supported Pleat, Cartridge Type B:

   a. American Air Filter Co., Inc.
   b. Farr Co.
   c. Cambridge Filter Co.

2.3 REPLACEABLE (THROWAWAY) PANEL PRE FILTERS, TYPE A

A. Description: Factory-fabricated, viscous-coated, flat-panel type, replaceable air filters with holding frames in sizes and having performance characteristics as indicated.

B. Media: 2 inch throwaway media of interlaced glass fibers, sprayed with nonflammable adhesive. 30 percent ASHRAE Standard 52.1 to remove 30 percent of all particles exceeding one (1) micron in size.

C. Frame: Cardboard frame with perforated metal retainer.

D. Duct Holding Frames: 20-gage galvanized steel capable of holding media and media frame in place, with gaskets to prevent unfiltered air bypass.

2.4 EXTEND SURFACE, SUPPORTED PLEAT, CARTRIDGE FINAL FILTER, TYPE B

A. General: Air filters shall be 65 percent efficiency, extended surface, self-supporting, 12” pleat type. Each filter shall consist of a rigid ultra-fine glass fiber, media pack, securely-bonded to a double wall enclosing frame. Each filter shall be furnished with a holding frame.

   1. Types:

      a. The filter shall have an average atmospheric dust spot efficiency of 65 percent as determined by the ASHRAE 52.1 test method. The rated filter face velocity shall be 450 fpm with an airflow capacity of 5500 cfm and initial resistance of 0.50 inches water gage. The final resistance shall be 1.20 inch water gage. Provide type similar to American Air Filter Varicel II.

   2. Side access housing: See article 2.5.

2.5 SIDE ACCESS HOUSING

A. Construction:

   1. The commercial side access housing shall be part of the air handling unit. See Section 15854, “Central - Station Air-Handling Units”.

2. Provide hinged and recessed access doors on both sides of each housing with hinges and pins, and include permanently attached positive locking door latches. Filter tracks shall include nylon pile seal to mate with the sealing face of all filters. Gaskets shall be provided to prevent air leakage around doors and between the doors and the filters.

2.6 FILTER GAGES

A. General: See specification and installation in Section 15975, "Control Systems - Electronic and Direct Digital Controls".

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install air filters and holding devices of types indicated, and where shown on the drawings. Install air filters in accordance with air filter manufacturer's written instructions and with recognized industry practices to ensure that filters comply with requirements and serve intended purposes.

B. Filter Element and Media Protection: Protect filter elements and media against dirt during construction, and do not operate until system is thoroughly cleaned.

1. Filters must be in regular operating condition before the fans to which they are connected are energized for any purpose, such as temporary ventilation or adjusting.
2. After all adjustments are completed and immediately before filters are accepted for regular operation, they shall be provided with a complete new media.
3. Type B filters shall not be installed until the system is ready for balancing.
4. Prefilters shall be used alone or temporary panel filters will be used in place of the Type B filters.

C. Filters: Joints between holding frames of filters and enclosing ductwork shall be gasketed, caulked or sealed against air leakage.

1. Provide access doors 20 inches wide by the maximum available height in air handling unit casings for servicing and removal of filters. Smaller size will be permitted if suitable for accessing all parts of filter installation.
2. Filter chamber shall be sized for operator to conveniently perform all operations.
3. Temporary filters and replacement filters:

a. Temporary filters: Prior to operation of systems with filters, provide all necessary temporary filters of types as scheduled in sub-paragraph below.

1) Prior to system balancing provide all temporary filters and replace filters when dust loading exceeds manufacturer's recommendations or efficiency of system filters is impaired.

b. Replacement filters: Prior to final acceptance of systems or operation of systems by the Government, replace temporary filters as noted in Temporary Filter Schedule.

1) Notify COR in writing no less than 7 days before systems are operated for beneficial use of the Government and temporary filters or filters or filter media used during balancing period are replaced. In absence of such notice, filters or filter media shall be replaced on or after starting date of guarantee period.

c. Temporary Filter Schedule:

1) Type A system filter: temporary filters shall be equivalent to Type A. Replace filters before balancing and before final acceptance or turning over to the Government.
2) Type B system filter: temporary filter shall be Type B. Replace filters before balancing, before final acceptance, or before turning over to the Government.

a) Replace Type A and B filters before final acceptance or turning over to the Government.

3.2 COMMISSIONING TESTS

A. General: Operate installed air filters to demonstrate compliance with requirements. Check all edges of filters and frames for air leakage of unfiltered air while system is operating. Correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise remove and replace with new units, and proceed with retesting.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of filters and filter frames and electrical wiring. Report results in writing.

3.4 CLEANING

A. After testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 15886

SECTION 15891 - METAL DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes indicated. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round ducts and formed fittings.
3. Duct liner.

B. Related Sections include the following:

1. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 REFERENCE STANDARDS

A. Air Movement and Control Association (AMCA)

B. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

1. “HVAC Applications” 1995 Edition, Chapter 34.
2. “Fundamentals” 1997 Edition, Chapter 32, Table 9 and Figure 14.

C. American Society for Testing and Materials (ASTM)

1. A36: Specification for Carbon Structural Steel.
2. A123: Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. A480: General Requirements for Flat-Rolled, Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
4. A653: Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
5. A700: Standard Practices For Packaging, Marketing, And Loading Methods for Steel Products for Domestic Shipment.
6. A 924 Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
7. B633: Specification for Electro-Deposited Coatings of Zinc on Iron and Steel.
8. C411: Test Method for Hot Surface Performance of High Temperature Thermal Insulation.
9. C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
10. C518: Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
11. C916 Specification for Adhesives for Duct Thermal Insulation.

12. C1071: Thermal and Acoustic Insulation (Glass Fiber, Duct Lining Material)
13. E84: Test Method for Surface Burning Characteristics of Building Materials.
14. G 21: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
15. G 22: Standard Practice for Determining Resistance Of Plastics to Bacteria.

D. American Welding Society (AWS)

1. D1.1: Structural Welding Code Steel.
2 D9.1: Sheet Metal Welding Code.

F. North American Insulation Manufacturers Association (NAIMA)

1. Fibrous Glass Duct Liner Standard

G. National Fire Protection Association (NFPA)

1. 90A: Installation of Air Conditioning and Ventilation Systems.

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

1. Duct construction standards.
2. Fire, smoke and radiation damper installation guide for HVAC systems.

I. Underwriters Laboratories (UL)

1. 181: Standard for safety factory-made air ducts and air connectors.

1.2 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:

1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
2. Joints: Joints include girth joints; branch and sub-branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.3 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by COTR. Accompany requests for

layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 SUBMITTALS

A. Prepare submittal data in accordance with procedures of Division 1 Section, "Submittals."

B. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:

1. Thermal/Acoustic Duct Liner and associated materials.
2. Sealing Materials.
3. Fire-Stopping Materials.
4. Duct Materials
5. Duct Joints and Seams
6. Hangers, supports, and associated materials

C. Shop Drawings: CAD-generated and drawn to 1/4 inch equals 1 foot scale. Show fabrication and installation details for metal ducts on drawing sheets the same size as the Contract Drawings.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project including terminal units, coils, humidifiers, and filters.
10. Duct accessories, including access doors and panels.
11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
12. Custom-built mixing boxes for AHU's 12 and 13.

D. Welding certificates.

E. Field quality-control test reports.

F. Record drawings including duct systems routing, fittings details, reinforcing, support, and installed accessories and devices.

G. Prepare and distribute operations and maintenance data as specified in Division 1 Section, "Operation and Maintenance Manual Data."

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NAIMA Compliance: Comply with Fibrous Glass Duct Liner Standard.

C. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

D. SMACNA Compliance: Comply with the following SMACNA Standards:

1. HVAC Duct Construction Standards.
2. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.

E. ASHRAE Compliance: Comply with the following ASHRAE guidelines:

1. “HVAC Applications” 1995 Edition, Chapter 34.
2. “Fundamentals” 1997 Edition, Chapter 32, Table 9 and Figure 14.

F. Warranty: The Warranty shall include a service and parts warranty for one year from the date of acceptance of the installation, without charge to the Government. After completion of the original installation, provide service and parts incidental to the proper performance of the equipment under the warranty for the period of one year. Calibrate and adjust the equipment provided under this contract. Place them in complete operating condition subject to the approval of the COTR.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and fire-stopping materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle sealant firestopping materials in compliance with manufacturers recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with 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: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

D. 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.

2.2 DUCT LINER

A. Fibrous-Glass Liner: Comply with NFPA 90A and with NAIMA AH124.

1. Known Acceptable Source:

   a. CertainTeed Corp.; Insulation Group.
   b. Johns Manville International, Inc. Permacote Linacoustic R-300.
   c. Owens Corning.

2. Materials: ASTM C 1071 Type II; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.

   a. Thickness: 1 inch and 2 inch as indicated on drawings.
   b. Nominal thermal R-Value:

      1) 4.3 hr x sq. ft. x deg F/BTU for 1 inch thick acoustical duct liner
      2) 8.4 hr x sq. ft. x deg F/BTU for 2 inch thick acoustical duct liner

   c. Nominal Sound Absorption Coefficients as tested per ASTM C423

	Sound Absorption Coefficients (Type A Mounting) at						
Thickness	Frequency (Cycles per second)						
(In)	125	250	500	1000	2000	4000	NRC
1	0.08	0.32	0.72	0.99	1.07	1.00	0.8
2	0.26	0.73	1.10	1.10	1.04	1.03	1.00

   d. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   e. Resistance to microbial growth: Duct liner shall include cleanable acrylic coated air surface with immobilized EPA registered anti-microbial agent. Duct liner shall not support the growth of fungus or bacteria, as determined by tests in accordance with ASTM G21 and G22.
   f. Velocity rating: Rated for use at air velocities up to 4000 feet per minute, per requirements UL-181 erosion test.
   g. Liner Adhesive: Comply with NFPA 90A and with ASTM C 916.
   h. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner

when applied as recommended by manufacturer and without causing leakage in duct.

1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics. Seal joints all around with mastic and mesh. Sealing only the corners is not acceptable.

B. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.

C. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, non-flammable, non-toxic, waterproof, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts. Petroleum or solvent based sealants shall not be permitted due to their inherent hazardous vapor. Sealant shall not crack with age and shall remain flexible to allow for thermal expansion of duct with a service temperature of minus 20 degrees F to 400 degrees F. Sealant shall comply with the requirements of ASTM C916.

1. Known Acceptable Source: Rectorseal Air-Lock 181.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

E. The duct sealing materials shall conform to SMACNA requirements.

2.4 FIRE-STOPPING

A. Refer to Division 7 Section, “Fire Stopping”.

2.5 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, or structural-steel fasteners appropriate for construction materials to which hangers are being attached. Do not use powder actuated concrete fasteners.

B. Hanger Materials: Galvanized steel, round, threaded rod.

1. Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel rod diameters.
2. Duct hangers shall not be longer than 4 ft.
3. Strap hangers are not permitted.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.6 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement. Joints shall be configured to give maximum rigidity to the joint with an airtight seal.

1. Known Acceptable Source:

a. Ductmate Industries, Inc. Type 25 or 35.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Known Acceptable Source:

a. Ductmate Industries, Inc.

2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
3. Longitudinal Seams: Pittsburgh lock sealed with water based sealant. Edges and slips shall be hammered down to leave a smooth interior duct finish.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

E. Ducts shall conform to the dimensions indicated, and shall be straight, and smooth on the inside, with joints neatly finished. Seams and joints in duct system shall be sealed to withstand a the indicated pressures and shall be finished to a smooth surface and made completely airtight. Apply sealant in accordance with manufacturers recommendations. Sealants shall be water based; petroleum or solvent based sealants will not be permitted due to their inherent

hazardous vapors. Sealant on exposed duct shall be applied in a manner which results in smooth surface free of runs, cracks, holes an splatter on adjacent surfaces.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive containing an EPA registered Anti-microbial coating/agent that resists microbial growth as determined by ASTM G21 & G22.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary. Where longitudinal seams are unavoidable, apply adhesive coating on seam.

F. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

G. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

1. Fan discharges.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts.

H. Terminate liner with build-outs attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other build-out means are optional; when used, secure build-outs to duct walls with bolts, screws, rivets, or welds.

2.8 ROUND DUCT AND FITTING FABRICATION

A. Round, Longitudinal- or Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Duct Joints:

1. Ducts up to 20 Inches Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.

C. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

D. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

E. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:

   a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:

   a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.

4. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
5. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
6. Round Elbows Larger Than 14 Inches in Diameter: Fabricate gored elbows unless space restrictions require mitered elbows.
7. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
8. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
9. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

2.9 AHU'S 12 AND 13 MIXING BOX FABRICATION

A. AHU mixing boxes shall be custom built on-site by the sheet metal contractor with 18 gauge galvanized steel sheet metal in accordance with this specification. Mixing box shall be insulated with 2" thick duct liner in accordance with this specification. Seams shall be sealed air tight with duct sealant. Mixing box shall include insulated, hinged access doors on both sides. Submit shop drawings to COR for approval prior to construction.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts: 3-inch wg
2. Return Ducts (Negative Pressure): 3-inch wg.
3. Exhaust Ducts (Positive and Negative Pressure): 1-inch wg .
4. Outdoor Air Ducts: (Negative pressure): 1-inch wg

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures. Maintain clear working space for electrical equipment in accordance with building code and National Electrical Code (NFPA 70).

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Fire Stopping."

O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and Division 15 Section, “Mechanical Seismic Protection.”

P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

Q. Install control dampers and air flow measuring stations provided under Sections 15910, “Duct Accessories” and 15975, “Control Systems - Electronic And Direct Digital Control.”

R. Provide sufficient access doors to permit future cleaning of the interior surfaces of the lined ductwork.

S. Round branch duct connections to rectangular main shall be bellmouth spin-in fittings in accordance with SMACNA Duct Construction Standards.

T. Rectangular branch duct connections to rectangular main shall be 45 degree entry fittings in accordance with SMACNA Duct Construction Standards.

3.3 SEAM AND JOINT SEALING

A. Maximum Allowable Leakage: As described in ASHRAE Handbook, "Fundamentals" Volume. Comply with requirements for leakage classification 12 for rectangular ducts in pressure classifications less than and equal to 2 inches water gage (both positive and negative pressures), and leakage classification 6 for pressure classifications greater than 2 inches water gage. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Flexible duct shall be supported at no greater distance than 4 feet. Maximum permissible sag is 0.5 inches per foot of spacing between supports. Ducts may rest on truss supports. Support system must not damage duct or cause ot of round shape. Hangers or supports shall be no less than 1.5 inches wide.

E. Do not install powder-actuated concrete fasteners.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Contract with an independent testing agency to perform, record, and report leakage tests.

B. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports. Submit report to COTR for approval:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable. Provide final report confirming that ducts meet leakage requirements.

3.7 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. 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.
3. 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.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

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.
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.

F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

END OF SECTION 15891

SECTION 15910 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Manual volume control dampers.
3. Automatic control dampers.
4. Fire dampers, fire and smoke dampers.
5. Turning vanes.
6. Duct-mounted access doors and panels.
7. Flexible connectors.
8. Flexible ducts.
9. Accessories hardware.

1.2 REFERENCE STANDARDS

A. National Fire Protection Association (NFPA)

1. 90A: Standard for installation of air conditioning and ventilating systems.
2. 90B: Standard for installation of warm air heating and air conditioning systems.

B. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

1. HVAC Duct Standard.
2. Fire, smoke and radiation damper installation guide for HVAC systems.

C. Underwriters Laboratories (UL)

1. 555: Fire dampers.
2. 555S: Smoke dampers.
3. 181: Factory made air ducts and air connectors.

1.3 SUBMITTALS

A. Product data including details for materials, dimensions of individual components, profiles, and finishes for the following items:

1. Backdraft dampers.
2. Manual volume control dampers.

3. Automatic control dampers.
4. Fire dampers, fire and smoke dampers.
5. Duct-mounted access panels and doors.
6. Flexible ducts.

B. Shop drawings from manufacturer detailing assemblies. Include dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail the following:

1. Special fittings and volume control damper installation (both manual and automatic) details.
2. Fire/smoke damper installation, including sleeves and duct-mounted access door and panel installation.

C. Product Certification: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static pressure loss, and dimensions and weights.

D. Automatic Control Damper Schedule: Provide damper schedule indicating duct size, damper size, damper type, damper model number, damper torque requirements, actuator torque capability, actuator type, actuator model number.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA Standards:

1. NFPA 90A.

B. SMACNA Compliance: Comply with SMACNA "HVAC Duct Construction Standard" and "Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems."

1.5 EXTRA MATERIALS

A. Furnish extra materials matching products installed as described below, packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to FAA .

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 BACKDRAFT DAMPERS

A. Description: Suitable for horizontal or vertical installation.

B. Frame: 3-1/2 inches x 1 inch x 16 gage hot-dip galvanized steel hat channel, with welded corners and mounting flange.

C. Blade Frames Seals: Ethylene Propylene Terpolimer (EPT) sponge seals.

D. Blade Seals: Dual durometer vinyl.

E. Blade Axles: Galvanized steel. Bearing pressed fit flanged ball.

F. Tie Bars and Brackets: 5/16 inch galvanized steel.

G. Return Spring: Adjustable tension.

H. Wing-Nut Operator: Galvanized steel, with 5/16 inch galvanized-steel rod.

I. Pressure Drop: Not to exceed 0.28 inches water gage at face velocity of 1000 fpm.

J. Leakage: Hot to exceed 26 cfm per sq ft, at 0.5 inch water gage differential pressure, and 70 deg F.

K. Known Acceptable Source: Ruskin, or American Warming and Ventilating.

2.2 MANUAL VOLUME CONTROL DAMPERS

A. General: Provide factory-fabricated volume-control dampers, complete with required hardware and accessories. Stiffen damper blades to provide stability under operating conditions. Provide locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class. Provide end bearings or other seals for ducts with pressure classifications of 3 inches or higher. Extend axles full length of damper blades. Provide bearings at both ends of operating shaft.

B. Single Blade Volume Control Dampers: Single-blade, standard leakage rating, suitable for horizontal or vertical applications. Damper shall include; 22 gage galvanized steel frame and blade, synthetic bearings, 3/8 inch steel shaft, and temperature rating of 250 deg F.

1. Known Acceptable Source: Ruskin MD-25.

C. Multiple Blade Volume Control Dampers: Multiple opposed blade, standard leakage rating, with linkage outside of air stream, suitable for horizontal or vertical applications. Damper shall include; 16 gage galvanized steel frame and blades, synthetic bearings, 1/2 inch steel shaft, and temperature rating of -40 deg F to 240 deg F.

1. Known Acceptable Source: Ruskin MD-35.

D. Single Blade Round Volume Control Dampers: Single-blade, standard leakage rating, suitable for horizontal or vertical applicaitons. Damper shall include; 20 gage galvanized steel frame and blade, synthetic bearings, 3/8 inch steel shaft, and temperature rating of 250 deg F.

1. Known Acceptable Source: Ruskin MDRS-25.

E. Damper Control Hardware: Zinc-plated, die-cast core with a heavy-gage dial and handle made of 3/32 inch tick zinc-plated steel, and a 3/4 inch hexagon locking nut. Provide center hole to suit damper operating rod size. Provide elevated platform for insulated duct mounting.

2.3 AUTOMATIC CONTROL DAMPERS

A. Type: Opposed blade dampers for modulating service and parallel blade dampers for 2-position service. 2-position dampers used for Dilution Ventilation balancing shall be opposed blade.

B. Frames: Construct Frames of five inch by one inch extruded aluminum hat channel with a minimum of 0.125-inch wall thickness.

C. Blades: Blades not exceeding six inches wide, and of heavy gage extruded aluminum airfoil shape to minimize pressure loss across the damper.

D. Bearings, shafts, and linkage: Bearings shall be of nylon or oil impregnated sintered bronze. Shafts made of heavy-duty steel shall be extended six inches beyond frame and is marked for damper blade position. Provide linkage of 1/8 inch by 1/2-inch aluminum tie bars located out of the air stream, concealed in the frame.

E. Seals: Provide replaceable resilient seals along top, bottom and sides of frame and along edge. Damper and seals shall comply with UL flame and smoke rating of 25/50.

F. Ratings: Rate damper for minimum 2000 fpm air velocity at 2.5 inches static pressure; damper leakage not exceeding 0.5 percent of total CFM (4.00 CFM/sq. ft.) based on 2000 fpm and one inch static pressure when tested per AMCA Publication 500. Damper shall be rated for a temperature range of minus 70 to 200 deg F. Submit leakage and flow characteristics data with shop draw.

G. Maximum System Pressure: Dampers shall be rated for no less than a maximum system pressure of 8.5” w.g. for a 36” blade length.

H. Torque requirements: Dampers shall require maximum 8 in-lb./square foot operating torque, based on 1 inch static pressure and 1000 FPM velocity. Submit actuator torque requirement with shop drawings.

I. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, Ruskin Company, Model CD-50.

2.4 FIRE DAMPERS

A. Fire dampers shall be UL labeled according to UL Standard 555.

B. Fire dampers shall be dynamic type and rated for 1-1/2 hours.

C. Fire damper frames shall be Type B fabricated with roll-formed 20 gage, galvanized steel; with mitered and interlock corners.

D. Fire damper sleeve thickness shall be per SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems Table 2-2, but not less than 20 gage. Sleeve width shall comply with manufacturer's written installation instructions, and as a minimum shall extend six inches beyond the fire partition surface on both sides of the partition.

E. Provide fire dampers that are designed for horizontal or vertical mounting orientation as indicated.

F. Fire damper blades shall be roll formed interlocking 24 gage galvanized steel. Blades shall be out of the air stream when retracted.

G. Provide replaceable 165 deg F fusible link.

H. Known Acceptable Sources:

1. Air Balance Co. Model 319 BLV.
2. Ruskin Model DIBD2.

2.5 FIRE/SMOKE DAMPERS

A. Provide fire/smoke dampers of the type and size indicated. Each combination damper shall be rated in accordance with UL 555 Leakage Class II , UL 555S, and bear the UL listings stamp. Each combination damper shall be equipped with a UL classified 120 vac electric damper actuator and fire sensor. Fire sensor shall electronically and mechanically lock damper in a closed position when duct temperature exceeds 212 deg F and still allow override of fire sensor to operate damper as may be required for smoke control functions. Damper shall not be operable while temperature is above 250 deg F. Fire sensing package shall include two damper position indictor switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when damper is fully open; the other switch shall close when damper is fully closed. Fire sensor and position indicator switches

shall be capable of interfacing electrically with smoke detectors, building fire alarm systems, direct digital control panel, and remote indicating control stations.

B. Known Acceptable Sources:

1. Air Balance Co., Model 120 AJ
2. Ruskin Manufacturing, Model FSD 60.

2.6 ACTUATORS

A. Damper Motors for automatic control dampers: See Section 15975, "Control Systems - Electronic and Direct Digital Controls."

2.7 TURNING VANES

A. Fabricate turning vanes according to SMACNA HVAC Duct Construction Standards.

B. Manufactured Turning Vanes: Small, curved, double-walled type for uniform air distribution and change of direction. Air shall leave turning vanes parallel to side walls of duct.

C. Acoustic Turning Vanes: Fabricate of airfoil-shaped aluminum extrusions with perforated faces and fiber glass fill.

D. Known Acceptable Source: Duro-Dyne Vane Rail.

2.8 DUCT-MOUNTED ACCESS DOORS AND PANELS

A. General: Provide construction and airtightness suitable for duct pressure class.

B. Provide access door at volume dampers where duct size is over 24 inches, and at location of all backdraft dampers, control dampers, fire/smoke dampers, and location indicated on drawings.

C. Frame: 22 gage galvanized sheet steel. Provide with bend-over tabs and foam gaskets.

D. Door: Double-wall, 24 gage galvanized sheet metal construction with insulation fill and thickness. Provide continuous piano hinge and cam latches. Furnish a round transparent plexiglass inspection window, on access doors serving gravity backdraft dampers only.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber seals.

F. Insulation: 1-inch- thick fiber glass or polystyrene foam board.

G. Known Acceptable Source: Ruskin, model ADHW.

H. Install ACCESS DOORS on upstream of backdraft dampers, and downstream of control/smoke dampers, unless otherwise noted, and instructed by COTR.

2.9 FLEXIBLE CONNECTORS

A. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL Standard 181, Class 1, provided with insulation.

B. Standard Metal-Edged Connectors: Factory-fabricated with a strip of fabric 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 24-gage, galvanized sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected duct system. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA HVAC Duct Standard.

C. Transverse Metal-Edged Connectors: Factory-fabricated with a strip of fabric 3-1/2 inches wide attached to 2 strips of 4-3/8-inch-wide, 24-gage, galvanized sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected duct system. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA HVAC Duct Standard.

D. Conventional, Indoor System Flexible Connectors Fabric: Glass fabric double coated with polychloroprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.

E. Known Acceptable Source: Duro Dyne Corp.

2.10 FLEXIBLE DUCTS

A. General: Comply with UL 181, Class 1.

B. Flexible Ducts - Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch-thick, glass fiber insulation around a continuous inner liner.

1. Reinforcement: Steel-wire helix encapsulated in the inner liner.
2. Outer Jacket: Glass-reinforced, silver mylar with a continuous hanging tab, integral fiber glass tape, and nylon hanging cord.
3. Inner Liner: Polyethylene film.

C. Known Acceptable Source: Duro Dyne Corp.

2.11 ACCESSORIES HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket and a flat mounting gasket. Size to allow insertion of pitot tube and other testing instruments and provide in length to suit duct insulation thickness.

B. Splitter Damper Accessories: Zinc-plated damper blade bracket, 1/4-inch, zinc-plated operating rod, and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.

C. Flexible Duct Clamps: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action. Provide in sizes from 3 to 18 inches to suit duct size.

D. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of duct accessories. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install duct accessories according to manufacturers installation instructions and applicable portions of details of construction as shown in SMACNA standards.

B. Install volume control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner.

C. Provide test holes at fan inlet and outlet and elsewhere as indicated.

D. Install fire/smoke dampers according to the manufacturers UL-approved printed instructions.

E. Install access doors where indicated and at each automatic control damper and at each air flow measuring station. Label access doors according to Section 15050, “Basic Mechanical Materials and Methods”.

F. Install automatic control dampers according to the manufacturers printed instructions. Ensure that damper are installed square and that they operate freely. Coordinate damper actuator installation requirements with Section 15975, “Control Systems - Electronic and Direct Digital Controls”.

3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual dampers is specified in Section 15990, “Testing, Adjusting, and Balancing”.

END OF SECTION 15910

SECTION 15932 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.

B. Types of outlets and inlets required for project include the following:

1. Ceiling air diffusers, grilles, and registers.

1.2 REFERENCE STANDARDS

A. Air Diffusion Council (ADC)

1. 1062 - Certification, Rating and Test Manual.

B. Air Movement and Control Association (AMCA)

1. 500 - Test Method for Louvers, Dampers, and Shutters.

C. Air-Conditioning and Refrigeration Institute (ARI)

1. 650 - Standard for Air Outlets and Inlets.

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

1. 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.

E. American Society for Testing and Materials (ASTM)

1. B221 - Standard for Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.

F. National Fire Protection Agency (NFPA)

1. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3 QUALITY ASSURANCE

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

B. Provide Air Inlets and Outlets manufactured in accordance with the following standards and ratings:

1. Tested and rated in accordance with ARI 650.
2. Tested and rated in accordance with ASHRAE 70.
3. Tested and rated in certified laboratories under requirements of ADC 1062.
4. Inlets and outlets shall bear the ADC Certified Rating Seal.
5. Tested and rated louvers in accordance with AMCA 500.
6. Louvers shall bear AMCA Certified Rating Seal.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings. Indicate selections on data.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors in a waterproof area, store above grade and enclose with waterproof wrapping.

1.6 MAINTENANCE

A. Spare Parts: Furnish to the Government, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

PART 2 - PRODUCTS

2.1 CEILING AIR DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule.

1. Diffuser Finishes:

a. White Enamel (W-E): Semi-gloss white enamel prime finish.

E. Known Acceptable Source:

1. Titus Products Div.

2.2 REGISTERS AND GRILLES: RETURN AND EXHAUST AIR

A. General: Except as otherwise indicated, provide manufacturer's standard wall and ceiling registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.

C. Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall and ceiling systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

D. Types: Provide return and exhaust air grilles of type, capacity, and with accessories and finishes as listed on Return Register and Grille Schedule.

1. Grille Finishes:

a. White Enamel (W-E): Semi-gloss white enamel prime finish.

E. Known Acceptable Source:

1. Titus Products Div.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions, in accordance with recognized industry practices, and in accordance with NFPA 90A to insure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.

C. Locate ceiling air diffusers, registers, and grilles, as indicated on architectrual "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

END OF SECTION 15932

SECTION 15933 - AIR TERMINALS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Single-duct air terminal units.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans and under floor plans, 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 assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

1.3 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated.

B. 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.

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.4 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 SINGLE-DUCT AIR TERMINAL UNITS WITH HOT WATER REHEAT COIL (TYPICAL FOR VAV-1 THROUGH 20)

A. Available Manufacturers:
   1. Titus, Model ESV

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

C. Casing: 22 gauge galvanized steel.
   1. Casing Lining: 1-inch- thick, non-porous, sealed liner complying with UL 181 AND NFPA 90A. Liner shall comply with ASTM G21 and G22 for fungi and bacterial resistance.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections. Sizes shown on mechanical drawings.
   4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: Shall not exceed 1 percent of maximum inlet rated airflow at 3-inch wg inlet static pressure.
   2. Damper Position: Normally open.

E. Attenuator Section: 22 gauge galvanized steel sheet metal.
   1. Lining: 1-inch- thick, non-porous, sealed liner complying with UL 181 AND NFPA 90A. Liner shall comply with ASTM G21 and G22 for fungi and bacterial resistance.

F. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested to 300 psig; and factory installed. Coil performance data shall be based on tests run in accordance with ARI Standard 410.

G. DDC Controls: Terminal unit controls shall be furnished and installed by the local Johnson Controls Inc. (JCI) representative. The new DDC controls shall integrate with the existing JCI Metasys system.

H. DDC Controls: Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with temperature controls specified in Division 15 Section "Electronic and Direct Digital Controls" and shall have the following features:
1. Damper Actuator: 24 V, normally open.
2. Valve Actuator: 24V, normally open.
3. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
   a) Proportional, plus integral control of room temperature.
   b) Time-proportional reheat-coil control.
   c) Occupied and unoccupied operating mode.
   d) Remote reset of airflow or temperature set points.
   e) Adjusting and monitoring with portable terminal.
   f) Communication with temperature-control system specified in Specification Section 15975.

2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 – PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

D. Connect ducts to air terminal units according to Division 15 Section "Metal Ducts."

E. Ground units with electric heating coils according to Division 16 Section "Grounding and Bonding."

F. Connect wiring according to Division 16 Section "Conductors and Cables."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Where ductwork dimensions on mechanical drawings differ from actual inlet and outlet dimensions of approved terminal units, the mechanical contractor shall fabricate sheet metal transitions in accordance with SMACNA Sheet Metal Standards to connect the ductwork to the terminal units.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

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 and do the following:
      a) Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
      b) Verify that controls and control enclosure are accessible.
      c) Verify that control connections are complete.
      d) Verify that nameplate and identification tag are visible.
      e) Verify that controls respond to inputs as specified.

3.5 TRAINING

A. Engage a factory-authorized service representative to train FAA maintenance personnel to adjust, operate, and maintain propeller unit heaters.
   1. Provide three sessions, 2 hours each, to train FAA maintenance personnel on procedures for starting and stopping, troubleshooting, servicing, and maintaining equipment.
   2. Provide training in accordance with this section and Section 01820, “Demonstration and Training.”

END OF SECTION

SECTION 15965 – LEAK DETECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Design, furnish, and install a complete cable-type leak detection and location system consisting of a microprocessor based monitoring unit, sensor cable, probes, system layout map and auxiliary equipment required to provide continuous monitoring of the sensing string(s) for leaks, shorts, breaks and probe activations. If any of these conditions should occur at any point along the cable, an alarm shall sound, type of condition shall be clearly identified and the location clearly displayed, and a supervisory alarm shall be sent to the existing JCI Metasys front end personal computer (FEPC). See mechanical drawings for leak detection locations.

1.2 MANUFACTURER

A. The system shall be the PAL-AT Leak Detection and Location System manufactured by PermAlert, Niles, Illinois, (847)-966-2190, or equivalent. The manufacturer shall have at least ten years experience in supplying leak detection systems.

1.3 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1. FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)
   Class No.3610 -Intrinsically Safe Apparatus and Associated Apparatus
2. UNDERWRITERS LABORATORIES (UL)
3. UL 913 -Intrinsically Safe Apparatus and Associated Apparatus

PART 2 - PERFORMANCES

2.1 SUMMARY

A. The Leak Detection System shall locate the point of origin of the first liquid leak or fault (break/short/probe) within ± .1% of the sensor string length, or ± 5 feet, whichever is greater. The system shall identify the type of alarm leak/break/short/probe as well as the location. The system shall be able to monitor (detect and locate) with up to 100' of cable wetted without significant inaccuracy in location.

2.2 SENSING STRING LENGTH

A. The system shall be capable of monitoring up to 5,000 feet of cable per sensor string from a single monitoring unit.

2.3 MULTIPLE LEAKS

A. The system shall be capable of monitoring (detecting and locating) for multiple leaks or additional liquid on the sensor cable. The system shall be able to monitor with up to 100 feet of cable wetted with reduced location accuracy.

2.4 BREAKS AND SHORTS

A. The system shall be capable of identifying the location of breaks and shorts on the cable. When either of these faults occurs, an alarm shall sound and a display visible on the front of the monitoring unit shall clearly indicate the type of fault, i.e. BREAK or SHORT and display the location of the fault. A supervisory alarm shall be sent to the existing JCI Metasys FEPC during an alarm condition.

2.5 LIQUIDS DETECTED

A. The system shall be capable of detecting water-based liquids at a maximum temperature of 250 degrees F.

2.6 REMOTE ANNUNCIATION

A. The system shall provide relays for remote indication of an alarm condition. The relays shall provide indication that no alarm conditions exist, an alarm condition exists but has not yet been acknowledged, and an alarm condition exists and has been acknowledged. Communications shall be available via RS-232 and ASCII communication protocol to allow central point monitoring and control via a remote computer.

2.7 ARCHIVES

A. The system shall record significant events in nonvolatile memory. A minimum of 900 events shall be stored. When the memory becomes full, the recorded events shall be deleted from memory on a FIFO basis. Each recorded event shall include the time and date that the event occurred. Archives shall be retrievable through the RS-232 and ASCII communication protocols.

2.8 SYSTEM STATUS

A. The system shall continuously provide positive indication that it is monitoring the sensing string and the status of the sensing string. The system clock shall provide the time and date on the LCD of the monitoring panel. The system clock shall be programmable by the user. A time and date indication shall be included for all events recorded in memory.

2.9 SECURITY

A. The system shall have assignable password security to provide for varying levels of system access. A minimum of 20 passwords shall be available within the system. The system shall not permit unauthorized modifications to the sensing string to be made (i.e. shortening the cable length) without causing an alarm condition.

2.10 SENSOR TYPES

A. The system shall be capable of monitoring sensor cables, probe sensors and switch sensors (such as float switches, pressure switches, etc.) from the same monitoring panel. English language displays shall indicate the status of the sensors.

2.11 SENSITIVITY

A. The system shall not detect incidental liquid contact that is not at least equivalent to a small puddle. 3 inches in diameter. The sensitivity of the system shall be field adjustable to increase or decrease the amount of wetted cable needed to cause an alarm from several inches to several feet.

PART 3 - PRODUCTS

3.1 MONITORING UNIT

A. The monitoring unit shall be microprocessor based and capable of monitoring up to 5,000 feet of sensing string per cable, including sensor cable, probes and jumper cable, depending on cable type. The monitoring unit shall indicate when any liquid comes in contact with the sensor cable by sounding an alarm, actuating the two output relays, displaying a message stating that a leak has been detected and the location of that leak on the sensing string. A supervisory alarm shall be sent to the existing JCI Metasys FEPC during an alarm condition.

B. The monitoring unit shall have a green LED on the front panel to indicate the unit is powered. A 2-line by 40-character backlit LCD shall be visible from the front of the unit to provide system data. A red LED on the front panel shall indicate an alarm condition has occurred.

C. The monitoring unit power requirements shall be 120/240 VAC, 100 VA, 50/60 Hz, single-phase. Monitoring units shall be equipped with an RS-232 communication port and a minimum of one common and one per cable SPDT output relay, rated for 250 VAC, 10 A.

D. The monitoring unit shall be enclosed in a modified NEMA 12 enclosure. The unit shall be UL Listed and FM approved to provide connections for intrinsically safe sensor circuits for use in Class I. Division I, Groups C and D Hazardous Locations. The ability to locate a leak shall not depend on battery backed up functions. In the event of power failure, system conditions and parameters shall be stored in nonvolatile memory allowing the unit to automatically resume monitoring, without resetting, upon restoration of power. An on-off switch shall be provided in the panel for servicing.

3.2 SENSOR CABLE

A. The sensor cables shall be suitable for use with the monitoring unit. The sensor cables shall be of coaxial construction consisting of an insulated copper center conductor, a suitable spacer material and an outer braid.

B. All coaxial sensor center conductors must not be less than 14 AWG for mechanical strength.

C. All cables must be capable of field installation of connectors by trained technicians. The cable shall be available in lengths up to 1,500 feet in bulk spools. All cables must be field

repairable by trained technicians. Cable on flat surfaces shall have hold down clips every 8 feet and cable identification tags every 50 feet.

PART 4 - INSTALLATION

4.1 GENERAL

A. The system shall be installed per the manufacturer's recommended installation procedures. All local, state and federal codes and requirements shall be followed. The system shall be installed by properly trained personnel.

4.2 GRAPHIC LOCATOR MAPS

A. A location map shall be provided with the system by the installing contractor; indicating the "As Installed" system configuration and sensing string layout. Footage along the cable shall be provided as references to locate leaks. Footage shall be based upon Calibration Points taken per Section 4.3.

4.3 CALIBRATION POINT

A. The installing contractor shall be responsible for taking and recording calibration points along the sensing string per the manufacturer's recommended procedures. All cable not in containment piping shall have cable tags every 50 feet.

4.4 FIELD TEST OF SYSTEM

Tests shall be performed to demonstrate the ability of the system to detect and locate breaks, shorts and probes on the sensor string. The cable shall be shorted with the alarm and location verified. Leak testing shall be done per the following procedure to verify operation and ability to work with condensation pools of other static moisture.

A. Wet the sensor cable near the start of the sensor string and acknowledge the detection/location alarm and remap the system.
B. Wet the sensor cable near the end of the sensor string with the first location still wetted and acknowledge the detection/location alarm and remap the system.
C. Wet the sensor cable in three additional locations between the first and second leak location with each detection/location alarm being acknowledged and all prior leak locations still wetted.

Prepare and submit a report verifying each leak location and each detection accuracy. Furnish a history print out of the test results from the panel. Submit TDR traces for each test run to allow verification of wet locations.

4.5 FIELD TECHNICAL ASSISTANCE

A. The contractor shall provide manufacturer's technical assistance for contractor, training, installation inspection, start up and owner operating and maintenance training. Contractor

shall follow all manufacturer's instructions for installation. A time domain reflectometry graph of the cable installation shall be furnished at time of owner training.

B. The contractor shall comply with all manufacturer's instructions in regards to installation of the system including design requirements.

END OF SECTION

SECTION 15975 - CONTROL SYSTEMS - ELECTRONIC AND DIRECT DIGITAL CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. The control system shall be an addition to the existing Johnson Controls system currently installed in the facility.

B. This Section includes Direct Digital Control Panels (DDCPs) capable of monitoring and controlling all heating, ventilating and air conditioning (HVAC) equipment, and variable air volume terminal units indicated. The Direct Digital Control System (DDCS) shall monitor and control all system points through twisted pair cabling and shall interact with the existing DDCS and Front End Personal Computer (FEPC). The existing FEPC is a data processing system specifically designed to monitor and control the HVAC systems through the DDCPs, or other control units. This Section includes control equipment for HVAC systems and components for the Automation Wing Second Floor and Attic.

1. Provide new DDCPs for control of all HVAC equipment installed including, but not limited to, air handlers, VAV boxes, pumps, humidifiers, and exhaust fans.
2. Provide new direct digital VAV box Microprocessor Controllers (MC) which communicate via a Local Area Network to the New DDCP. VAV boxes shall be as specified in Section 15933 Air Terminals. All control wiring and conduit for the VAV boxes shall be installed by the control system installer. 120 VAC power for the VAV box MCs is provided by Division 16 in junction boxes in the attic. The control system installer shall extend the power wiring from these junction boxes to each VAV box MC.
3. The new DDCPs shall be functionally tied into the existing DDC system.
4. The new DDCPs shall be functionally tied into the existing FEPC.
5. Provide all software and firmware upgrades required, for the existing DDCPs and FEPC, to interface the new DDCP and new direct digital VAV box MCs with the DDCS and FEPC. Software for the entire system shall be upgraded to the latest available version for the entire DDCS.
6. The DDCP shall be capable of accepting analog and digital input in accordance with the control diagrams and the DDCP point function schedule.
7. Provide DDC system control wiring and conduit for this DDC system in accordance with Division 16. Division 16, Electrical provides 120 VAC power to the DDCP. The control system installer shall make final connections as necessary to complete the system. Provide 120 VAC control power from the essential branch circuit where required but not provided

under Division 16. Coordinate requirements with Division 16 and COR. Submit cable and conduit routing plan.

8. Monitor fire alarm system alarm outputs for the Automation Wing Second Floor and Attic through existing Johnson Controls N1 bus interface to the FACP, or through addressable control modules to a DDCP. Coordinate installation with Section 13850.
9. Transfer existing start/stop points for exhaust fan EF-1B from existing Data Gathering Panel to a new DDCP as specified in the DDCP point function schedule on the mechanical plans. Provide new current relays to sense the status of each fan.
10. Install new Control Wing Attic leak detection system to detect leaks in the drip pan below the new and existing heating and chilled water piping above the Control Room and the humidifier drip pans.

1.2 AIR TRAFFIC CONTROL EQUIPMENT RESTRICTIONS

A. Job Conditions: Do not permit interference with the air traffic control function at the Center. Schedule and plan work to permit normal facility operations to continue with minimum of disruption. Access to the facility shall be kept unobstructed at all times. If interference with the existing facility operations seems to be unavoidable, advise the COR 24 hours prior to such interference. Proceed as directed by the COR.

B. Equipment Shutdown: Each ARTCC maintains air traffic control continuously without shutdown. Various techniques are employed to achieve maximum system availability. Mechanical and electrical systems in direct support of air traffic operation and environmental systems have redundant configurations. Shutdown of equipment shall be scheduled with the COR at least 24 hours prior to the DDCP installer's need. The reliability of mechanical and electrical systems is compromised when redundant equipment is not available. Every effort will be made by the FAA to allow work to be accomplished during the installer's normal working hours; however, the COR may require that certain equipment be shut down during off normal hours and be restored to service immediately after this period. See drawing G008 for list of off normal hours. Shutdown shall be accomplished by FAA personnel.

1.3 RELATED SECTIONS

A. Section 15050, "Basic Mechanical Materials and Methods" contains requirements that relate to this Section.

B. Section 15100, "Valves" contains requirements that relate to this Section.

C. Section 15170, "Motors" contains requirements that relate to this Section.

D. Section 15171, "Variable Frequency Drives" contains requirements that relate to this Section.

E. Section 15185, "Hydronic Pumps" contains requirements that relate to this Section.

F. Section 15810, "Humidifiers" contains requirements that relate to this Section.

G. Section 15850, "Air Handling" contains requirements that relate to this Section.

H. Section 15854, "Central-Station Air-Handling Units" contains requirements that relate to this Section.

I. Section 15933, "Air Terminals" contains requirements that relate to this Section.

J. Section 15965, “Leak Detection” contains requirements that relate to this Section.

K. Section 16050, "Basic Electrical Materials and Methods" contains requirements that relate to this Section.

L. Section 16100, "Raceways, Boxes, and Cabinets" contains requirements that relate to this Section.

M. Section 16120, "Wires and Cables" contains requirements that relate to this Section.

N. Section 13850, "Fire Alarm and Detection Systems" contains requirements that relate to this Section.

1.4 REFERENCE STANDARDS

A. The current issues of the following documents in effect on the date of the invitation for bids form a part of this specification and are applicable to the extent specified herein.

1. Electronic Industries Association (EIA):

a. TIA-232 Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Exchange.
b. TIA-422 Electrical Characteristics of Balanced Voltage Digital Interface Circuits.
c. TIA-485 Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
d. TIA-568 Commercial Building Telecommunications Wiring Standard

2. National Fire Protection Association (NFPA):

   a. 70 National Electric Code
   b. 72 National Fire Alarm Code
   c. 90A Standard for the Installation of Air Conditioning and Ventilating Systems
   d. 262 Standard Method of Test for Fire and Smoke Characteristics of Wires and Cables

3. Underwriters Laboratories (UL):

   a. 268 Smoke Detectors for Fire Protective Signaling Systems.
   b. 468A Wire Connectors and Soldering Lugs for Use With Copper Conductors.
   c. 916 Energy Management Equipment Listing.

4. Federal Communications Commission (FCC):

   a. 47 CFR Part 15, Subpart B - Unintentional Radiators

5. National Electrical Manufacturer's Association (NEMA):

   a. ICS-6 Enclosures for Industrial Control Systems

1.5 DEFINITIONS

A. Modulating Control: Direct digital closed loop Proportional + Integral + Derivative (PID) control which maintains the controlled variable (temperature, humidity, etc.) at a setpoint by adjusting the position of a valve, damper or similar controlled device in small increments and decrements between fully open and fully closed positions. PID loop shall include an adjustable deadband which is a range of the controlled variable around the setpoint in which no change in output to the controlled device is made. Deadbands shall be initially set at plus or minus 0.5 degrees F. for temperature control loops and plus or minus 2 percent RH for humidity control loops.

B. 2-Position Control: On/off control in which the controlled device is either fully open or fully closed with no intermediate operating positions available.

1.6 SYSTEM DESCRIPTION

A. Provide a complete control system including, but not limited to, DDC controllers, raceways, wiring, thermostats, control valves, valve operators, control dampers, damper operators,

temperature and humidity sensing elements, flow and pressure sensing elements, element wells, regulators, and relays.

B. Control system hardware consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories connected to direct digital controllers to operate mechanical systems according to sequences of operation specified. Direct digital VAV box MCs shall be connected to existing distributed controller network operating in a multitasking, multi-user token-passing network.

C. Control system software consists of control software, communication software, alarm reporting software, and graphical operator interface software, programmed to operate mechanical systems according to sequences of operation specified.

1.7 SEQUENCE OF OPERATION

A. Setpoint Adjustment: The setpoints listed below are initial settings which shall be adjustable. DDCS software data for the air handling units including but not limited to setpoints, differentials, alarm limits, and proportional and integral control parameters shall be adjustable through the FEPC and POT.

B. Alarm Limits: Alarm limits shall be set as shown on the DDCP point function schedule on mechanical plans. The alarm limits may be changed during start-up, if required, to meet actual operating conditions.

C. Variable Air Volume Air Handling Units (AHU-12 and 13).

1. Hand-Off-Auto Operation: A Hand-Off-Auto operation switch shall be provided as part of the variable frequency drive. In the OFF mode, the units shall not operate. In the HAND mode the fan shall operate in the occupied mode as described below. In the automatic mode, unit start stop functions shall be controlled by the DDCP. The toilet exhaust fan (EF-1A) and the general exhaust fans (EF-2,5,6,7) shall be interlocked to operate as described below.
2. Variable Frequency Drive Bypass: The variable frequency drive is provided with a across the line starter to allow the fan to be operated at full speed when the frequency drive is not available for operation. If either AHU-12 or AHU-13 is operated in this mode, interlock the respective supply damper (CD-4,8) to open before the fan is started. Raise the minimum CFM for every VAV box to 60% of the maximum. All other dampers, heating control valves (FCV-1,3), cooling valves (FCV-2,4) and humidifiers shall operate as described below in the occupied mode.

3. Supply Damper Control: Interlock supply dampers (CD-4,8) to open before the respective air handler fan is started and close when the fan is stopped. The supply fan shall not be started until its respective supply damper is fully open as sensed by a limit switch.
4. Fire/Smoke Control: If the supply detectors (S-1, 2) sense smoke or the fire alarm system indicates a zone fire alarm, the supply fans (AHU-12,13 through hard-wire interlock), exhaust fans (EF-2,5,6,7), and toilet exhaust fan (EF-1A) shall be stopped. The outdoor air dampers (CD-2,3,6,7), the supply air dampers (CD-4,8) and the exhaust air dampers (CD-9,10,11,12) shall close. The return air dampers (CD-1,5) shall open.
5. Occupied-Unoccupied-Automatic: Provide occupied - unoccupied - automatic sequence of operation in the DDCP. In the automatic mode, AHU-12 and AHU-13 shall be switched between "occupied" and "unoccupied" mode according to a daily program (time) schedule which includes a holiday feature. When "occupied" or "unoccupied" mode is selected by the operator, the units shall operate as specified for each type of unit mode.
6. Unoccupied Cooling Mode: When any space temperature, as sensed by the VAV box temperature sensors, rises above 83°F, start the lead air handling unit AHU-12 or AHU-13. If the lead air handling unit fails to operate, start the lag air handling unit. The exhaust fans (EF-1A,2,5,6,7) shall be off. The outside air dampers (CD-2,3,6,7) and exhaust air dampers (CD-9,10,11,12) shall be closed, the return air dampers (CD-1,5) shall be open to their maximum position. The unit heating valves (FCV-1,3) shall be fully closed and the unit cooling valves (FCV-2,4) shall be modulated to maintain the discharge air temperature at its unoccupied cooling setpoint which is adjustable and initially set at 55°F. All zone VAV terminal unit dampers shall be modulated to maintain space temperature. All VAV box reheat control valves shall be fully closed. When all of the space temperatures drop below 80°F, the operating air handling unit, AHU-12 or AHU-13, shall be stopped.
7. Unoccupied Heating Mode: In the unoccupied heating mode, the zone VAV terminal unit dampers and the VAV box reheat coil valves shall be modulated to maintain the unoccupied heating setpoint which is adjustable and initially set at 65°F. When any space temperature, as sensed by the VAV box temperature sensors, drops below 63°F, start the lead air handling unit (AHU-12 or AHU-13). If the lead air handling unit fails to operate the lag unit shall be started. The exhaust fans (EF-1A,2,5,6,7) shall be off. The outside air dampers (CD-2,3,6,7) and exhaust air dampers (CD-9,10,11,12) shall be closed, the return air dampers (CD-1,5) shall be open to their maximum position. The unit cooling valves (FCV-2,4) shall be fully closed and the unit heating valves (FCV-1,3) shall be modulated to maintain the discharge air temperature at its unoccupied heating setpoint which is adjustable and initially set at 90°F. When all of the space temperatures rise above 65°F, the operating air handling unit AHU-12 or AHU-13 shall be stopped.
8. Warm-Up Mode: At a predetermined time (initially set at 30 minutes) prior to occupancy, a warm-up cycle shall be initiated if any space temperature as sensed by the VAV box temperature sensors is below 68°F. During the warm up cycle, operate AHU-12 and AHU-13 continuously. The exhaust fans (EF-1A,2,5,6,7) shall be off. The outside air dampers

(CD-2,3,6,7) and exhaust air dampers (CD-9,10,11,12) shall be closed, the return air dampers (CD-1,5) shall be open to their maximum position. The unit cooling valves (FCV-2,4) shall be fully closed and the unit heating valves (FCV-1,3) shall be modulated to maintain the discharge air temperature at its warm-up setpoint which is adjustable and initially set at 90°F. The zone VAV terminal unit dampers and the VAV box reheat coil valves shall be modulated to maintain the occupied space temperature setpoint. When all of the space temperatures rise above 70°F, the warm-up cycle shall be terminated and both air handling units shall be switched into the occupied mode.

9. Cool-Down Mode: At a predetermined time (initially set at 30 minutes) prior to occupancy, a cool-down cycle shall be initiated if any space temperature as sensed by the VAV box temperature sensors is above 82°F. During the cool-down cycle, operate AHU-12 and AHU-13 continuously. The toilet exhaust fan (EF-1A) shall be off. The exhaust fans (EF-2,5,6,7) and dampers shall be controlled as described below for the occupied mode except that the minimum outdoor air dampers (CD-3,7) shall remain closed if the outdoor air enthalpy is greater than the return air enthalpy. The unit heating valves (FCV-1,3) shall be fully closed and the unit cooling valves (FCV-2,4) shall be modulated to maintain the discharge air temperature at its cool-down setpoint which is adjustable and initially set at 55°F. All zone VAV terminal unit dampers shall be modulated to maintain the occupied space temperature. All VAV box reheat coil valves shall be fully closed. When all of the space temperatures drop below 79°F, the cool-down cycle shall be terminated and the unit shall be switched into the occupied mode.
10. Occupied Fan Control: In the occupied mode, both AHU-12 and AHU-13 shall operate continuously. Provide the operator with the capability to stop either AHU-12 or AHU-13. Each system shall continue to operate as specified. At the end of the occupied mode, both AHU-12 and AHU-13 shall stop and all related control devices shall be returned to their normal positions.
11. Occupied Mode - Damper Control: The minimum outside air dampers (CD-3,7) shall be modulated to maintain minimum outside air cfm, as sensed by outside air flow measuring stations (AFMS-1, 3). The minimum outside air cfm setpoint at each AHU, which is adjustable, shall be initially set at 2150 cfm. Whenever the minimum outside air dampers (CD-3, 7) are opened, exhaust damper CD-9, associated with exhaust fan EF-2, shall also open. Exhaust damper CD-9 shall close when the minimum outside air dampers close. The return air and outside air temperature and relative humidity shall be sensed to provide input data for enthalpy control of economizer cycle by the DDC system. As the outside air enthalpy drops below the return air enthalpy, the outside air dampers (CD-2,6) and return air dampers (CD-1,5), shall be modulated in sequence with the heating (FCV-1,3) and cooling (FCV-2,4) valves to maintain the discharge air temperature setpoint which is adjustable and initially set at 55°F. The mixed air temperature sensor (TS-3,7) shall proportionally override the discharge sensor (TS-4,8) to prevent the mixed air temperature from dropping below its setpoint which is adjustable and initially set at 50°F. When the

outdoor air enthalpy exceeds the return air enthalpy or the outdoor air temperature exceeds 70°F, the dampers shall be returned to their normal positions. When the outside air dampers are operating in the economizer cycle, the minimum outside dampers shall be maintained in the open position that was fixed when the economizer cycle began.

12. Occupied Mode - Heating And Cooling: The cooling coil valve shall be modulated in sequence with the dampers and heating valve to maintain the discharge temperature as sensed by (TS-4,8) at setpoint. The setpoint shall be adjustable and initially set at 55°F.
13. Variable Frequency Drive: In all operating modes, the DDCP shall modulate the operating air handling unit's supply fan variable frequency drive (VFD) to maintain the lowest system static pressure as sensed by the duct static pressure measuring stations (SP-1,2) at setpoint. The supply air duct static pressure measuring stations shall be located approximately two thirds of the way down the supply duct as shown on the drawings. The static pressure setpoint shall be operator adjustable and initially set at 1 inch w.g. When both AHU-12 and AHU-13 are operating, they shall be controlled at the same speed. When only one air handler is operating and the second is commanded to start, reduce the speed of the operating unit to 20%, start the second unit, bring the second unit speed up to 20% and then allow the static pressure control signal to control speed as specified above. Provide failure of airflow (pressure) alarm at the FEPC if loss of air flow is sensed by SP-1 or SP-2.
14. High Static Pressure Safety: The manual reset static pressure safety switch (DP-3,4) located on the discharge of each supply fan (AHU-12,13) shall stop its respective supply fan upon sensing a differential pressure above its setpoint which is adjustable and initially set at 4.0 inches w.c. Locate high pressure sensing port upstream of all dampers and air flow measuring stations. Vent switch low pressure sensing port to the attic space.
15. Freezestat: The manual reset freezestat (FZ-1,2) located on the downstream side of the coils shall stop the respective air handler (AHU-12,13), return dampers to their normal position, and fully open the heating coil flow control valve (FCV-1,3) and the cooling coil flow control valve (FCV-2,4) if the heating coil discharge air temperature drops below 40°F.
16. Pre-Heat Re-circulation Pump Control: When the mixed air temperature, as measured by TS-3 & 7, is above 40 °F the pre-heat re-circulation pump, shall be off. When the mixed air temperature, as measured by TS-3 & 7, is below 40 °F, regardless of the status of the unit, the pre-heat re-circulation pumps, P-12 and P-13, shall be started and run continuously.
17. Humidifier Controls: The humidifiers (HU-1,2) shall only be operated in the occupied mode when its respective fan (AHU-12,13) is operating at a speed greater than 20%. The lowest humidity signal from room air humidity sensors (HS-5,6) shall, through the DDCP, modulate the humidifiers (HU-1,2) to maintain the desired 40% space relative humidity. The supply duct humidity sensor (HS-7,8) shall override the room humidity sensors to prevent the humidity in the duct from exceeding a high limit of 85%. Differential pressure sensors (DP-5,6) shall prevent the humidifiers from operating when no or low air flow is sensed.

18. Toilet Exhaust Fan Controls: Toilet exhaust fan EF-1A shall be started whenever either AHU-12 or AHU-13 is operating in the occupied mode.
19. General Exhaust Fan Controls: When both AHU-12 or AHU-13 are off, or either AHU-12 or AHU-13 is operating with only minimum outside air, exhaust fans (EF-2,5,6,7) shall be deactivated and their respective two position exhaust dampers (CD-10,11,12) shall be closed. Exhaust damper CD-9 shall operate in conjunction with the minimum outside air dampers as described above, under Occupied Mode. When the air economizer cycle is in operation, outside air airflow measuring stations (AFMS-1,3) shall measure their respective duct CFM. Their summed CFM, through the DDCP, shall control the exhaust fans and related dampers according to the schedule below. When each fan (EF-2,5,6,7) is commanded to start, its associated damper (CD-10,11,12) shall open and after a time delay, the respective exhaust fan shall start. On fan shutdown, the fan shall stop before the damper closes. The supply air flow measuring sensors (AF-2,4) provide supply CFM readouts for each fan.

    a. When the outdoor air CFM is increasing:

        1. At 4,382 CFM (40% of 10,827 CFM) open CD-09 and start EF-2.
        2. 6,364 CFM (59% of 10,827 CFM) open CD-10 and start EF-5.
        3. 8,346 CFM (77% of 10,827 CFM) open CD-11 and start EF-6.
        4. 10,328 CFM (95% of 10,827 CFM) open CD-12 and start EF-7.

    b. When the outdoor air CFM is decreasing:

        1. At 10,328 CFM (95% of 10,827 CFM) stop EF-7 and close CD-12.
        2. 8,346 CFM (77% of 10,827 CFM) stop EF-6 and close CD-11.
        3. 6,346 CFM (59% of 10,827 CFM) stop EF-5 and close CD-10.
        4. 4,382 CFM (40% of 10,827 CFM) stop EF-2 and close CD-09.

20. VAV Box Reheat Controls: The variable air volume terminal unit controllers (MC) shall provide reheat coil control as shown. The reheat coils shall be controlled by 2-way flow control valves (FCV). Room sensors at sensing a drop in zone temperature shall modulate VAV terminal unit toward the minimum CFM limit. As space temperature continues to drop below set point, the reheat coil hot water control valves shall modulate open. As space temperature begins to rise, the sequence shall operate in reverse order. The valves shall modulate to maintain the zone occupied setpoint at all times except as required in the unoccupied and warm-up modes where they are controlled to the unoccupied and warm-up mode set points respectively.
21. Filter Monitoring: Differential pressure switches (DP-1,2) shall monitor the two-stage air filter plenum pressure drop and alarm at the FEPC when the pressure exceeds an adjustable

limit. Pressure difference indicators (PDI) located at the filters shall indicate the differential pressure across the filters.

22. Unoccupied Override: If during the unoccupied mode, any of the unoccupied mode override switches (located on each VAV box space thermostat) are activated, the system shall be switched back into the occupied mode for an adjustable time period which is adjustable at the FEPC and initially set at 2 hours.
23. Normal Positions: Whenever an air handler is off, all associated devices shall return to their normal positions unless expressly required by another part of this sequence of operation:

    a. Supply dampers: closed
    b. Minimum outdoor air damper: closed
    c. Maximum outdoor air damper: closed
    d. Return air damper: open
    e. Exhaust air damper: closed
    f. Variable Frequency Drive: speed = 0
    g. Heating valve: closed
    h. Cooling valve: closed
    i. Humidifier control: off
    j. VAV box damper: open
    k. VAV box reheat valve: closed

24. Failure Modes: Upon loss of power to the control device, each control device shall fail in the following state:

    a. Supply fan: last command
    b. Supply dampers: last command
    c. Minimum outdoor air damper: closed
    d. Maximum outdoor air damper: closed
    e. Return air damper: open
    f. Exhaust air damper: closed
    g. Variable Frequency Drive: local control
    h. Heating valve: open
    i. Cooling valve: open
    j. Humidifier control: off
    k. VAV box damper: last command
    l. VAV box reheat valve: last command
    o. Exhaust fans: last command

D. First Floor Exhaust Fan: Exhaust fan EF-1B shall run continuously. When AHU-11 duct smoke detector is activated, which is located on first floor, EF-1B shall stop.

E. Chilled and Hot Water System Monitoring Points: Monitor chilled water supply and return temperatures, chilled water differential pressure, hot water supply and return temperatures, and hot water differential pressure.

F. Fire Alarm System Monitoring.- Provide monitoring of the fire alarm system as listed in the DDCP point function schedule. Provide zoned control of the air handling units and exhaust fans based on the signals from the fire alarm system. A fire on the second floor or in the attic shall stop AHU-12,13 and exhaust fans EF-1A,2,5,6,7.

1.8 SUBMITTALS

A. General: Submit each item in this Section according to the Conditions of the Contract and Division 1 specification sections. Drawings shall be prepared using a Computer Aided Design (CAD) system. Upon successful installation, as-built drawings shall be delivered to the Government on CD-R discs in DGN (Microstation) compatible electronic format, as well as on full sized reproducible drawings. Drawings prepared for or used for this work shall become the property of the Government. The Government reserves the right to reproduce, in part or whole, the delivered drawings for internal Government purposes.

B. Control diagrams: Submit a control diagram for each system on an individual and separate sheet complete with a bill of material, a sequence of operation in a text format, sequence of operation in flow chart format, and tagging information. The diagram shall consist of a system flow diagram showing the location of each control device, a control schematic drawing showing the function of each item, scale drawings of the panel layouts of both inside and face plate, and a complete terminal drawing for electrical devices connected with the system controls. Submit DDCP point function schedule with the control diagram. In addition to the above requirements, submittals shall include:

1. Control diagram with required variables, air flow diagrams, ladder diagrams, and wiring diagrams. Control diagrams shall include at least the following: set points, reset ranges, throttling ranges, differentials, operating ranges, normal positions, controller action, dial ranges, voltage, currents, mounting locations, indicators, and terminal strip points.
2. Composite wiring diagrams: Submit complete, detailed control and interlock wiring diagrams. Show mechanical and electrical equipment furnished and all electrical interlocks, indicating terminal designation for all equipment. Respective equipment manufacturers shall furnish, through the supplier, approved drawings of equipment to be

incorporated in this diagram. Clearly differentiate between factory-installed and field-installed wiring.

3. Communication cable installation plan showing MC locations, raceway routing, and communication cable conductors.
4. Damper Schedule: Provide damper schedule indicating duct size, damper size, damper type, damper model number, damper torque requirements, and damper actuator type, damper actuator model number.
5. Valve Schedule: Provide valve schedule indicating valve model number, body type, Cv factor, actual pressure drop, actuator model number, and valve pressure shutoff rating.
6. Sequence of operation in text and computer flowchart formats: As a minimum, all control processes that are controlled by a digital signal shall be clearly shown both in text form and on the computer flowchart diagram. The flowchart shall show how each control action is derived.
7. Device tag schedule: Provide device tag schedule indicating device, identifier and DDCP software name.
8. Graphical Display: Provide samples of FEPC graphical displays which will be provided for each system.

C. Technical Specification Data Sheets: Documents supplied by the original manufacturer of the item. These documents include salient characteristics and shall be included in a special section of the instruction book titled Manufacturer's Literature.

1. Technical specification data for each type of product specified: Include manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, startup instructions, and maintenance instructions.
2. Technical specification data sheets for raceway, wire, cable and installation materials.
3. Technical specification data sheets for each software module, including the system theory.
4. Software documentation including descriptive data and sequence of operation, flow charts, and machine listings of operating, user, and application software including complete Programmer’s Manual tailored to the project. Control process and MC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequence to be easily interpreted and modified at any time in the future.

D. Installer qualifications: Submit resume listing installer’s qualifications including manufacturer’s certification as an approved system installer and a list of recently completed projects demonstrating 2 years of system installation experience. Provide name(s), address, and telephone numbers for installer supervisory personnel.

E. Startup personnel qualifications: Submit resume listing startup personnel qualifications including manufacturer's certification as an approved system technician and a list of recently completed projects demonstrating 2 years of system startup experience. Provide name(s), address, and telephone numbers for supervisory personnel.

F. Operation and Maintenance Manual: Provide operation and maintenance manual for control systems equipment as specified in Division 1, which also includes the following:

1. General troubleshooting and repair instructions.
2. Specific, explicit installation, troubleshooting, calibration, and repair instructions for each sensor, controller, interface device and controlled device.
3. Specific, explicit instructions for operation of each sensor, controller, interface device and controlled device.
4. Maintenance instructions and spare parts lists for each type of control device.
5. Interconnection wiring diagrams with identified and numbered system components and devices.
6. Keyboard illustrations and step-by-step procedures indexed for each operator function.
7. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
8. Calibration records, list of set points, differentials, alarm limits, alarm instructions, and time schedules.

G. Test plans and inspection reports specified in Part 3 of this Section.

H. As built drawing requirements located in Part 3 of this Section.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Engage an Installer specializing in control system installations with a minimum of 2 years of experience installing systems of similar type, size and complexity. Control system manufacturer shall certify that installer has been trained on the proper installation of this type of system and is an approved system installer.

B. Startup Personnel Qualifications: Engage specially trained personnel in direct employ of manufacturer of primary temperature control system with a minimum of 2 years of experience programming, testing and commissioning systems of similar size and complexity. Control system manufacturer shall certify that the startup personnel have been trained on the proper installation, programming, testing, and commissioning of the system.

C. Software Quality Assurance Plan: Provide a software quality assurance plan.

1. Describe in flow chart and narrative form, the quality assurance operations from contract award through final delivery which are utilized to assure the quality of the computer software and related documentation. The description shall include organizational responsibilities and planned inspection and test operations and shall be keyed or related to the major milestones or activities within each phase of the development process.
2. Standards and Procedures: Describe the contractor's standards and procedures (e.g., documentation, work, coding, testing) which will be used to support the software development and associated documentation. The standards and procedures shall specify criteria for use, and shall have controlled conditions for release and change. As a minimum, the plan shall address those standards and procedures necessary for the requirements, design, implementation, test, and documentation of the software provided.
3. Corrective Action, Reporting and Control: Describe the corrective action process used to assure the prompt reporting, tracking, analysis, and correction of problems and defects for all software and related documentation. Include those procedures and controls which shall assure that deficiencies are promptly documented and corrected and that appropriate action is taken to prevent repetition. The deficiency documentation shall identify problems or defects by severity (critical, major, minor), and by function (test, coding, documentation).

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this Section are factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.11 EXTRA MATERIALS

A. Line Replaceable Unit (LRU) and spares: Identify LRUs in the proposed systems by written description, part number, and manufacturer. An LRU is defined as the lowest unit to be replaced within the system during site corrective maintenance. It is a separate, installable, physical package, performing a single function or a group of closely related functions. An example of an LRU is a plug-in printed circuit card. These units shall be identified as parts common (readily available from several commercial sources in addition to the manufacturer) and parts peculiar (available only from the manufacturer) and shall indicate the exact source of each including price and lead time of each. Submit a unit price list for line replaceable units.

B. Reprocurement package: Submit a reprocurement package which includes documentation required to reprocure parts peculiar from alternate sources. This list shall identify:

1. Actual manufacturer of the part;

2. Unit cost;
3. Parts that are electrostatic sensitive;
4. Total usage for each unit LRU;
5. Historical failure rate; and
6. Schematics and board drawings.

C. Furnish one extra LRU of each type installed, packaged with protective covering for storage, and identified with labels clearly describing contents, as described below:

1. Space Temperature Sensor;
2. Space Humidity Sensor;
3. Water Temperature Sensor;
4. Water Differential Pressure Sensor;
5. Air Differential Pressure Switch;
6. Valve Actuator;
7. Valve Repair Kit;
8. Damper Actuator;
9. Micro Controller (MC); and
10. MC power supply.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Acceptable Manufacturer: The DDCPs and VAV box MCs installed under this contract shall be by Johnson Controls Inc. and shall be functionally tied into the existing Johnson FEPC and Metasys system. The VAV box MCs shall be tied into the existing Johnson network through the DDCP that serves the VAV air handling units. DDCPs, existing and new, shall interface and function with each other in a true peer to peer LAN architecture. The salient characteristics and interface requirements are set forth in this specification. The DDC controllers shall be Johnson Controls Metasys Network Control Units.

B. Manufacturer's Product Name: Johnson Controls Inc. uses the term Network Control Unit (NCU) to describe their DDCP. DDCP is used in this specification as a generic term for NCUs.

2.2 DIRECT DIGITAL CONTROL PANEL

A. General: All points on the DDCPs shall be communicated to the DDCS and the FEPCs. Upgrade existing firmware in the existing DDCP's to the most current revision.

B. System Operation: The DDCP, in conjunction with the new VAV box MCs, shall operate the HVAC equipment as described in the sequence of operation. The system shall include the following:

1. Software: The DDCP complete with software shall be capable of controlling and monitoring electrical equipment; heating, ventilating and air conditioning equipment; fire alarm and access controls and energy management systems. The DDCP shall be capable of monitoring and controlling system points using coaxial or shielded twisted pair cable and shall interface with the existing FEPC. The FEPC data processing system is specifically designed to monitor and communicate with DDCP.
2. Controllers: Microprocessor based processors, with one or more microprocessor based input/output (I/O) modules interfacing controllers to the sensors and output devices. The system shall utilize EPROM or RAM memory. RAM and the clock for EPROM/RAM systems shall be provided with power backup of four hour instant recharge capacitor or 12 hours trickle recharge batteries. Where RAM memory with EPROM backup is provided the memory shall be protected by a battery backup for a minimum of 72 hours. Controllers shall have memory error checking. Upon detection of a memory error, the controller processor shall correct the error or halt the unit to prevent erroneous operation. The DDCP shall be field proven. The DDC unit shall be listed in UL 916 PAZX.
3. Inputs and outputs:

    a. Analog Input: Analog inputs shall be compatible with RTD temperature sensors, 4-20 mA, 1-10 VDC or potentiometer inputs with 12 bit A/D conversion resolution minimum. Match inputs types to sensors provided.
    b. Analog Output: True analog output values shall be provided for control of end actuator devices and for data transmission to the existing FEPC. Overall analog output range of 0 to 10 volts or 0-20 mA with 8 bit D/A resolution minimum shall be provided.
    c. Digital Inputs: Digital inputs shall be processed for change of status. Alarm monitor points shall be assignable to normally open or to normally closed contacts.
    d. Digital Outputs: Digital outputs shall be assigned a priority with higher priorities able to override lower priorities. Controller digital, two position signals may operate the positioning device directly or have an interposing relay to give the proper signal level.
    e. Fail safe operation: Outputs shall be designed to interface with the equipment being monitored on a fail in place basis unless otherwise indicated. The DDCP shall interface with the existing control systems, in a manner that shall preserve the arrangements of the existing control systems upon loss of control from the DDCP. The last commands to the systems shall prevail. For such items as remote temperature adjustment, the reset signal shall maintain its last setting. Existing manual equipment start and stop control capabilities shall be maintained intact.

f. Panel capacity: Each DDCP shall have the ability to monitor, control and address the required data points. The mix of addressable points shall include analog inputs, analog outputs, discrete inputs and outputs in sufficient quantities to perform the function indicated.

4. Components: Control system shall include the following:

a. Communication port(s) on each DDCP to allow a simple plug in connection of the existing Portable programmer's Terminal (PPT) and the existing Portable Operator's Terminal (POT).
b. A peer to peer communication network to allow data exchange between remote DDCPs and FEPC at a minimum rate of 9600 bps.
c. An existing FEPC, associated operator stations, and software functioning as the primary operator interface for the DDCS.
d. MCs and DDCPs.
e. Processor cabinets.
f. Provide communication buses to serve new MCs.
g. Data communication between MCs, DDCPs and the FEPC shall be carried in a dedicated raceway.
h. Data shall be digitally displayed with properly located decimal point and two or three alphabetic characters on the CRT display of the FEPC, PPT and POT.
i. Provide incremental reset for precise setting of remote controllers. Such operation shall not interfere with alarm monitoring. Reset shall provide positive digital feedback of position.
j. When resistance bridge temperature measuring device is used, each point shall have independent open and zero adjustment.
k. Provide necessary devices for proper operation of control system, i.e. transmitters, sensors, temperature controllers and indicators, motors, linkages, flow control valves, relays and gages.
l. Prewired control cabinets containing:

1. Temperature indicators and temperature controllers;
2. Terminal strips;
3. Electrical relays - latching or magnetically held; and
4. Pressure switches.

m. Provide electronic equipment in accordance with the requirements of FCC Regulation, 47 CFR Part 15, Subpart B Unintentional Radiators, governing radio frequency electromagnetic interference and be so labeled.
n. Provide UL listed equipment.

o. Raceway, wiring, terminations and mounting of equipment to present a fully functional integrated system.
p. Calibrate devices, make final settings, and test control system under actual operating conditions for satisfactory performance.
q. Programmers terminal and FEPC point and graphics programming: The contractor shall prepare, document, and deliver site-specific program DDCP information. This work shall include, but not be limited to, producing new computer graphics display files, data point files, group point files, associated system tables, time-initiated programs, and analog high/low alarm limits for the new equipment and integrating into the existing DDCS and FEPC database. Install this data into the programmer's terminal and the FEPC.

5. DDCP reliability: The mean time between failure (MTBF) of the DDCP shall not be less than 6,000 hours for the installed systems. System failure shall be defined as single malfunction that causes loss of data or failure to function as specified.
6. Corrective maintenance time: Mean Time To Repair (MTTR) is defined as the elapsed time starting with DDCP failure or malfunction until the DDCP is again available for service, including checkout and warm up time required. The MTTR of the DDCP shall not be greater than two hours. Maximum repair time for failures shall not be greater than six hours. Corrective maintenance times are dependent on spare parts availability at the sites.
7. Data Control (D/C) and graphic summary: The following requirements indicate the hardware devices to be connected to the new DDCPs and the standard control software modules to be implemented. Provide additional software required to accomplish the detailed sequence of operations.

a. Point groupings: Points for each air handling unit shall be grouped together to provide a complete listing of all information associated with that unit on a single display screen. As a minimum, this shall include input points, output points, and setpoints.
b. Each analog point shall have unique remote panel resident dual high and dual low limit alarm thresholds set in engineering units. The first set of limits shall be warning limits which provide a normal band around the temperature setpoint. If the analog point exceeds these limits a warning shall be issued at the FEPC indicating that the analog value is out of its normal range. An alarm shall be generated at the FEPC if the analog point value exceeds the second set of limits. See DDCP point function schedule for list of alarm limits.
c. Each digital output shall have a software associated monitored input. Any time the monitored input does not track its associated command output within a programmable time interval, a command failed alarm shall be reported.

d. Where calculated points such as CFM are indicated, they shall appear in their respective logical groups. The respective unconditioned real data, such as the logarithmic differential pressure points, shall also be grouped in a special group for display and observation, independent of the logical groups.

e. Provide data and control points which are required to accomplish the digital control or energy management sequences indicated, but not listed on the DDCP point function schedule.

f. Unless otherwise indicated, the primary analog input and the analog output of each DDC loop shall be resident in a single remote panel containing the DDC algorithm, and shall function independently of peer or mux communication links. Secondary, reset type, analog inputs may be received from the peer network, but approved default values and procedures shall be substituted in the DDC algorithm for this secondary input if network communications fail or if the secondary input becomes erroneous or invalid.

8. Database Generation: The DDCP shall be provided with an on line data base generator to accomplish application program assignments; group and point assignments; data point modifications (additions and deletions); alarm parameter assignments; and peripheral assignments. Control adjustments shall be made directly through the keyboard of the FEPC. Systems requiring remote programming for these functions are not acceptable.

a. Changing program or application package parameters, adding data points, or deleting data points, shall not interfere with data processing or other application programs being executed.

b. Alarms shall be annunciated, printed, and control programs executed during program modes. Points in the system shall be monitored and controlled through DDCPs. Each DDCP in the system shall contain its own microprocessor and a memory with a minimum 72 hour battery backup. Each DDCP in the system shall be a completely independent stand alone master with its own hardware clock calendar, firmware and software to maintain control on an independent basis.

c. The DDCP shall have an identification label on the front of the door, and each component in the panel shall be identified by labels.

d. Each DDCP shall be capable of performing enthalpy or dry bulb switch-over (economizer and temperature compensated load reset).

e. Each DDCP shall be capable of storing and executing demand forecast programs, duty cycle programs, calculation point programs, and include the following capabilities:

1) Acquire, process, and transfer information to the FEPC operator workstations or other DDCPs on the same DDCP network.

2) Accept, process, and execute commands from the other DDCPs on the same DDCP network or the FEPC on the network.
3) Allow access to both data base and control functions by multiple workstations on the DDCP network at the same time. Provide plug-in connections for programmable terminals.
4) Record, evaluate, and report the changes of state and values that occur among points associated with the DDCP. If the FEPC or transmission network fails, and the power to the DDCP does not, the DDCP shall continue to perform control functions associated with the point connected to the network.

f. Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of subsidiary equipment. The DDCP shall provide both local and remote annunciation of detected component failures; or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDCP and shall not require the connection of an operator interface device.
g. DDCP software shall provide the equipment cycling protection. Control shall include a provision for limiting the number of times each piece of equipment may be cycled within any one hour period.
h. DDCP shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
i. Provide a multi-page set of graphic architectural displays showing each digital module including each remote panel, and communication links. Clicking on devices shall start an interactive dialogue allowing the user to observe the device status and to select device management options. Each device shall also be provided with an English descriptor of up to 60 characters.
j. RAM based digital devices may be uploaded or downloaded to or from the FEPC disk for backup archival.
k. Provide software to execute and observe diagnostics of remote device connected to the peer bus and the ability to deactivate and restart the device.
l. The operator shall be provided with the ability to override the use of the POT on remote DDCP from the existing FEPC.

9. Software: The DDCP complete with software shall provide a real time control language for HVAC system applications designed to accomplish easy transition from hardware control system design to local loop based control system design. The system software shall allow the user to provide control sequences directly into the controller and operators terminal memory. Selected input sensor data, parameters, and algorithms shall be entered into the system, and the result of the algorithms shall be used to position actuators. Modulating

control outputs shall be controlled through properly adjusted proportional plus Integral control loops.

10. Control algorithms: A control application package shall be provided to permit nonstandard control algorithms to be provided as part of the initial installation or added at a later date. An interpreter shall be EPROM or RAM resident in the programmers terminal. The control algorithms shall permit interlocks, calculations of BTUs, flows, and outputs, and provide hysteresis, scaling, offset, linearization, summation, multiplication, division, and other functions. Default modes, start up and check out tests, interlocks, demand control and other functions shall be provided utilizing these algorithms.
11. Controller local loops: Controllers shall be totally stand alone and independent of the central operator interface computer, i.e. the FEPC, for indicated control applications. Failure of the central operator interface shall in no way inhibit the operation or program execution of the controllers. Controllers software shall include a complete operating system, application packages as indicated, standard control algorithm application packages, and a user control and calculation application package complete with interpreter, and the following:

    a. EPROM or RAM resident operating system (OS), operating independently of central computers. The operating system shall control communications between the operators terminal, controllers and the input/output (I/O) modules, accept analog and digital inputs, produce analog and digital outputs, provide alarm monitoring, control application packages, and interface the necessary sensor and actuators. The controller OS shall also contain built-in diagnostic routines as indicated.
    b. Allow for scaling and for calibration of sensor lead length variations to insure instrument accuracy, and provide for automatic restart of equipment based on current program time without operator intervention.
    c. Provide a system advisory and alarm any time there is a loss of communication between the I/O microprocessor and the FEPC. In the event of I/O microprocessor failure provide a means for local or remote alarm. Also provide an override of selected output functions.
    d. Built in safeguards to prevent the DDCPs microprocessor from becoming captured by one control loop resident in DDCP. These built-in software safeguards shall be resident in nonvolatile memory.
    e. When the DDCP is disabled or in the event of a power failure to the DDCP, outputs shall remain in their last value to hold control valves, switches, and other DDC controlled devices in their last position at the time of disablement or power failure. Unless otherwise commanded by the FEPC or upon re-enablement of the DDCP, positions shall be maintained. Equipment that is operational prior to the time of DDCP disablement shall remain operational, and equipment that is idle shall remain idle.

12. Control groups: User control groups shall be provided to allow selected points to assume a control state based on the reception of a predefined initiator. The groups shall be logically constructed without regard to their physical location in the system. Each group shall have a sufficient number of points so that each point state to be assumed shall be individually assignable. The set or reset initiators may be calendar or elapsed time, event occurrences such as alarms, or inputs from an authorized operator. A control group sequence initiator shall override other action until a reset initiator is received or a manual operator request is made.
13. Alarms: Whenever a field point status exceeds preset limits, or there are other indications of system exceptions, alarms, error or failure, there shall be at least the following indications:

    a. The system shall sound an integral audible tone. The audible tone shall be capable of being enabled or disabled on operator command.
    b. The alarm point identification, along with individual point alarm messages, shall appear on FEPC using the standard TIA-232 interface and shall be copied on the FEPC printer. Upon operator command, a list of alarm points programmed into the DDC system, along with their alarm messages, shall be hard copied on the FEPC printer.

14. Memory and processing capability: Specifically, a DDCP shall contain memory and processing capability to perform the following in a stand alone mode:

    a. Scheduled start/stop; based on time of day, calendar, holiday, lead/lag schedule and temporary schedules;
    b. Adaptive start/stop;
    c. Duty cycling;
    d. Automatic temperature and humidity control;
    e. Demand control using a sliding window, predictive algorithm;
    f. Event initiated control;
    g. Calculated point including energy calculations;
    h. Scanning and alarm processing;
    i. Full direct digital control;
    j. Trend logging;
    k. Global communications;
    l. Maintenance scheduling;
    m. Communications with the FEPC;
    n. Night setback control;
    o. Variable frequency drive/CFM control;

p. Enthalpy or dry bulb switch-over (economizer); and
q. Temperature compensated load reset.

15. DDCP global communications: Each DDCP on the DDCP network shall have the ability to broadcast and receive point data onto the network, making that information available to other DDCPs in the system. Each DDCP shall have the ability to transmit and receive or I/O points as global points onto the network for use by other DDCPs on that controller network and to utilize data from other panels as part of its data base. To keep traffic on the network at a minimum, analog inputs shall be transmitted only after an operator specified change of value has occurred since the last broadcast value.
16. DDCP response time: It shall be possible to independently set the execution speed for each point in the DDCP to an operator selected time from 1 to 2 seconds.
17. DDCP upload and download capability: Each DDCP shall be able to download from, or upload to, FEPC operators workstation. Point data shall be modifiable from authorized FEPC operators workstation and downloaded to the DDCP over the DDCP network from the FEPC. It shall not be necessary to enter parameters locally at the DDCP for control programs to take effect. Each DDCP shall have continuous supervision of the integrity of DDCP data bases. In the event that DDCP on the network experiences a loss of its data base, the system shall automatically download a new copy of the respective data base to restore proper operation. Data base backup/download shall occur over the local area network without operator intervention. Operators shall have the ability to manually execute downloads of complete, or portions of a, DDCP data base.
18. Test mode operation: Each DDCP shall have the ability to place input/output points in a test mode. The test mode shall allow control algorithms to be tested and developed on line without disrupting the field hardware and controlled environment.
19. The treatment of I/O points in the test mode shall be as follows:

    a. Scanning and calculation of input points shall be indicated. Manual control to input points, i.e., setting the analog or digital input point to an operator determined test value, can be issued from FEPC operator workstations.
    b. It shall be possible to control output points, but only the data base state and value shall be changed, the external field hardware is left unchanged.
    c. Control actions on output points shall be enabled, but only the data base state and value shall be changed.

20. Communications loss: The DDCP shall continue, without interruption, to operate peripheral equipment if communications with the network bus is interrupted. Alarms shall be stored for up to 72 hours, or until memory is filled, and then when communications are restored, the alarms and abnormal operating conditions shall be transmitted to the FEPC.

21. DDCP power loss or component failure: Upon primary power loss to the DDCP, programs and point data shall remain resident for 72 hours and shall not require refreshment from the FEPC when power is restored. When the DDCP is disabled or in the event power is lost to the DDCP, outputs shall remain at their last value to hold control valves and other DDCP controlled devices in their last position at the time of disablement or power failure. Upon the resumption of normal power, the DDCPs shall analyze the status of controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation. These positions shall be maintained unless otherwise commanded by the FEPC or upon re-enablement of the DDCP.
22. System power: The entire system shall be connected to and powered by the essential branch circuits as indicated.
23. Real time clock. Routines shall be provided to maintain time of day, date and interval timers. The routine shall respond to periodic interrupts received from the FEPC and update designated memory locations with the current data.
24. Power fail-automatic restart interrupt: If power is removed and then restored, an interrupt shall be generated at one of the highest possible priority levels. This interrupt shall automatically cause the bootstrap operation to occur, which in turn shall call the automatic restart routines.
25. Data base manager: A menu data base manager shall be provided that manages data on an integrated, non-redundant basis. The data base manager shall allow additions and deletions to the data base without detriment to existing data.
26. Timer routine: A timer routine shall be provided that executes at the lowest foreground priority level. If a command fails to execute after a predetermined amount of time, a message shall be reported to the FEPC.
27. Error messages: Executing and operating system errors shall be reported to the FEPC.
28. Recovery from fatal errors: The DDCP shall automatically restart after an error occurs that halts operation. The automatic restart shall result in the DDCP returning to full operation.

2.3 FRONT END PERSONAL COMPUTER:

A. In room B117, replace existing front end personal computer (FEPC) with a new FEPC with monitor, keyboard, mouse, and color laserjet alarm printer; and install the latest software revision of Metasys Application and Data Server (ADS) software as specified herein. The hard drive to the existing FEPC shall be backed-up, and all files, information, software, and programming shall be transferred to the new FEPC (coordinate with Rick Munion). Provide as a minimum the following components for the new FEPC:

1. FEPC HARDWARE / SOFTWARE:

- **PC Hardware:** Intel Core 2 Quad Processor Q9400, 2.66 GHz (1333 MHz FSB), 4.0 GB RAM
- **Hard Drive Capacity:** 1 TB minimum

- **Network Interface Card:** Ethernet 10/100/1000 Mb
- **Combine CD/DVD Reader/Writer**
- **Graphics Support Video Card:** 256 MB onboard shared system memory
- **Sound Board:** Sound Blaster or compatible
- **Modem:** 56K
- **Monitor:** 24" Widescreen LCD Flat Panel, RGB & DVI, 1920 x 1200 Native Resolution, w/ height adjustment (Known acceptable source: Hewlett Packard W2408H)
- **Printer:** Color Laserjet with network interface
- **UPS:** APC 350VA Back-up power supply
- **Cables:** All required cables
- **Operating Software:** Latest Microsoft Windows operating system proven to be fully compatible with Metasys ADS.
- **Pre-loaded Software with installation CD or DVD:** Norton Anti-Virus, Microsoft Visio, Microsoft Office Professional 2007, Microsoft Windows Server Active Directory (latest version proven to be compatible with Metasys ADS)

JCI METASYS HARDWARE / SOFTWARE:

- **Software:**
  - JCI Application and Data Server (ADS) Software: Install existing ADS software to new FEPC and update to most current version
  - JCI Graphics Software: Install existing graphics software to new FEPC and update to most current version

INSTALLATION

- Install, update, and program Metasys ADS software for new FEPC
- Install and program graphics software for new FEPC
- Transfer all files, information, software, programming, and graphics from existing FEPC to new FEPC (coordinate with Rick Munion)
- Provide complete graphics programming of new work including:
  - Overall Graphic for the Automation Wing
  - Separate Graphic for the Basement, First Floor, Second Floor, Attic, and Roof of the Automation Wing
  - Separate Graphic for each system
  - Separate Graphic for each zone

2. Upgrading existing software: Upgrade the existing graphics software package and provide graphics as listed below. Provide graphical screen displays of each system and each system component in color. Provide individual, unique symbols for valves, fans, dampers, filters, and other mechanical and control system components. Arrange the symbols for each component so that the entire system is graphically represented. Graphical screen shall include dynamic display of associated temperature, pressure, flow and humidity readings as well as status indication of each associated digital point. Include the following:

   a. Temperature and flow control diagrams for Automation Wing Second Floor and Attic HVAC equipment;
   b. Fire alarm Monitoring points;

c. Direct Digital Control Panel Diagram;
d. Incorporate new DDCP and MC locations into existing floor plans; and
e. Incorporate new DDCP and MC loops into existing flow charts for critical loops.

3. Energy Management System (EMS): The existing FEPC is capable of accessing the existing energy management application program and associated data files. New equipment shall have the ability to be enabled or disabled based on existing EMS software logic.
4. FEPC and DDCP data relationship: Changes shall be accomplished utilizing the manufacturer's standard procedures and shall be capable of being done while the system is on line and operational. The network shall automatically check the data base files of the FEPC upon connection to verify a current data base match. An upload shall be initiated to update the file should it not be current.
5. Operator interface: Operator interface to the DDCP shall be made using the FEPC, PPT or POT. The interface shall:

   a. Accept data from the controller network on an as needed basis without having to scan the entire network of DDCPs for updated point data;
   b. Interrogate the controller network for updated point data when requested by the system operator;
   c. Allow operator command of devices at DDCPs on the DDCP network;
   d. Allow operator to place specific DDCPs in or out of service;
   e. Allow parameter editing of DDCPs;
   f. Store duplicate data base on file for every remote panel on the controller network and allow this data base to be downloaded to the DDCP while the system is on line using FEPC;
   g. Control or modify specific programs for each DDCP, i.e., demand, temperature control, and time scheduling using FEPC; and
   h. Develop, store, and modify dynamic color graphics utilizing system supplied graphics software using FEPC.

6. Maintenance management: Provide maintenance management software program for each DDCP. The DDCP acting in conjunction with the FEPC, shall have the capability to support a maintenance management program. This program as a minimum shall provide the following:

   a. Discrete run time monitoring on point by point basis for fans.
   b. Maintenance scheduling targets with auto annunciation, auto scheduling, and auto shutdown.

c. Equipment safety targets which generate an alarm or user defined message if the equipment has not been serviced and cleaned in time. The program shall also allow automatic shut down of the equipment if the safety limit is exceeded.
d. Single command reset on a point by point basis.

2.4 NETWORK AND COMMUNICATION

A. General: Data communications for the FEPC shall be provided by DDCPs over a network utilizing distributed processing control technology. The network shall employ a multi-tiered, true token passing concept. The transmission medium shall consist of coaxial cables.

1. Network bus. The bus shall be a high speed bus type network over which information is transmitted in a global fashion between each of the nodes or stations on the bus.
2. Network Node. The bus shall have the capacity to contain at least 29 stations or nodes at a minimum. A DDCP network gateway and each DDCP shall represent a node to the network. The bus shall connect the nodes in a fully distributed environment, each DDCP operating autonomously while communicating with other nodes on the network. Networks requiring a communicating controller are not acceptable.
3. Reconfiguration capability. A break in the communication path of the network shall be announced as an alarm and shall automatically initiate a DDCP network reconfiguration such that the resulting sections of the bus continue to function as separate networks. No loss of control shall result from such a break in the bus.
4. Transmission system. The network shall utilize dual network architecture to allow the DDCPs to share data as well as to globalize alarms. The network shall be based on the token passing technique with a data speed of not less than 9600 bps. Supervision of the network shall be accomplished by a flexible, roving, master station concept. The network shall provide for automatic reconfiguration if a station is added or lost. Should the transmission cable be cut, the two sections shall reconfigure with no disruption to the systems operation and without operator intervention. The DDCP network shall utilize a twisted, shielded cable for network transmissions.
5. Network protocol. The DDCP network shall be in accordance with TIA-485 for signal exchange operating at a minimum data speed of 9600 bps.
6. Direct Digital Control Interface (DDCI). The DDCI shall function as an interface or gateway between the FEPC and the DDCP network. That is, the DDCP shall interface data communications between TIA-232, 9600 Baud, and the Arcnet format and network protocol.

2.5 CONTROL PANELS

A. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located as indicated on drawings or adjacent to each system under automatic control if not indicated on drawings. Provide common keying for all panels.

1. Construction: NEMA 1 as defined in ICS-6 "Enclosures for Industrial Control Systems", totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color.
2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, changeover switches, and indicator lights.
4. Tags: Devices shall be permanently labeled with phenolic resin nameplates, black with white lettering, with minimum 1/4 inch lettering. Tag shall include device ID's as shown on as-built documentation and DDCP software identification. Internal and external wires shall also be labeled.

2.6 Variable air volume terminal unit control system.

A. General: The variable air volume terminal unit local area network controls shall be furnished by the DDC system control manufacturer. The VAV box Microprocessor Controller (MC) shall be a fully-functional direct digital controller. It shall be modular, and easily configured to satisfy multiple input/output needs. The MC shall contain its own control programs, energy management routines, and EPROM/EEPROM chips for stand-alone control and non-volatile memory. Devices not using non-volatile EEPROM or EPROM based operating system and application software shall be acceptable only if each controller is equipped with 120 hours of rechargeable battery backup and low battery level alarm indication at the associated space temperature sensors and FEPC. The MC shall contain pre-written "package" programs that can be implemented with a portable operators terminal (POT). The MC shall also be fully software programmable to meet the requirements of non-standard sequence of operations. The micro-computer based MC shall interface directly with sensors, actuators and environmental delivery systems (i.e., VAV boxes, air handling units, fans, lighting systems, etc.). Functionality of the MC shall include individual input/output point scanning, processing and control, alarm detection and transmission, and local operator terminal interface. The device shall be an analog and digital control device, utilizing true analog outputs. Specific hardware, control sequence and software requirements for these functions are as detailed in subsequent paragraphs of this specification.

1. The VAV microprocessor controllers (MC) shall utilize non-volatile program and parameter memory. The controller shall use a combination of EPROM/EEPROM. All

parameters, set-points, control routines, time settings, time programs, etc., shall be able to withstand power outages and power irregularities. Systems shall automatically return to normal operation after power is restored. No programming shall be required after a power failure.

2. The MC shall operate in a stand-alone manner, or communicate with other intelligent devices on a two-wire token-passing peer communication network, at a minimum of (9600) baud. Other intelligent devices include other MCs, FEPC and portable operators terminals (POT). MC's networked together shall be able to share information (i.e., point values, status, parameters) with each other.
3. The MC shall be capable of communicating with a DDCP and shall be fully integrated with all other building control systems. Point information on any MC shall be able to be displayed on the FEPC's CRT in logical groups mixed with points from other building automation systems (i.e., the facility primary DDC system, Life Safety system, etc.) Points shall be able to be displayed in dynamic graphic displays mixed with points from other facility systems;
4. The contractor shall be responsible for the integration of all Automation Wing building systems including the programming of the existing FEPC computer;
5. All point information shall be available for use by the DDCP and FEPC. When MC's are used for VAV box and fin tube radiation control, the VAV box actuator position and the fin tube radiation valve position may be used by the chilled water and hot water distribution system DDC controllers to reset the chilled and hot water loop temperatures;
6. Power line disturbance protection: Rapid on/off cycling of supply voltage shall not cause device failure or invalid relay or triac operation.

B. Hardware.

1. The MC shall be a microprocessor controlled device utilizing EPROM/EEPROM technology. To maximize efficiency and life of the product, as well as minimize heat generation and current draw, the MC shall utilize a solid-state board-level power supply. All memory shall be EPROM/EEPROM. All system modifications shall be done electronically. No potentiometers, dip switches, or other similar electromechanical devices shall be utilized.

2. Input/output capabilities include the following:

   a. 1000 ohm analog input;
   b. 0-10 Vdc analog input;
   c. Micro-bridge low differential pressure input;
   d. Dry contact digital input;
   e. 2-10 Vdc analog output;

f. Digital outputs;
g. Solid State 24 VAC switching (TRIAC); and
h. Form C relays;

3. The MC shall be of a modular configuration. Optional input and output modules shall be utilized to add additional point capacity to controllers where required. Controllers without modular input/output capability shall be provided with a minimum of 6 analog inputs, 2 analog outputs, 4 digital inputs, and 6 digital outputs. Do not use controllers without true analog outputs.
4. Static pressure inputs for all air flow measuring and control applications shall utilize a micro-bridge type sensor. Sensor shall have a sensitivity of plus or minus 2 percent of span;
5. Wiring from wall temperature sensor to MC and from MC to communication bus shall utilize modular connectors, to facilitate installation.
6. Temperature sensor shall contain a local override switch to switch from unoccupied to occupied status.

C. Variable Air Volume Box Accessories.- Provide the following additional hardware for VAV terminal unit applications.

1. Damper actuator: The damper actuator shall mount on the VAV box damper axle and shall provide complete modulating control of the damper. The motor shall have a closure torque of 35 in-lb. minimum. Full torque shall be applied at close-off to assure minimum leakage ratings.
2. Air flow pick-up: Provide a minimum of four air flow pick-ups. The output of these pick-ups shall be averaged and the result shall be an input to the control program resident in the controller. A multi-point averaging air flow pick-up and one differential pressure controller may be used in lieu of above.
3. Space temperature sensor: Provide a space sensor for each controller with an accuracy of plus or minus 0.5 deg F. The space sensor shall come complete with setpoint adjustment, unoccupied zone override switch and setpoint indicator. The Portable Operator Terminal (POT) shall connect into the system via a jack connector at the space sensor to display and change temperatures, flows, and setpoints.
4. Hot water valve: Fin Tube Radiation valves shall be straight through type as specified under flow control valves.
5. Transformer: Provide a transformer to supply required low voltage power for the VAV Microprocessor Controller. The primary side of the transformer shall be connected to a 120 Volt AC circuit provided under Division 16.

D. Variable Air Volume Microprocessor Controller Software

1. The MC shall operate totally stand-alone and independent of the DDCPs and FEPC for all specified control applications. Software shall include a complete operating system (OS), communications handler, point processing, standard control algorithms and specific control sequences. Software shall include built-in diagnostics. Systems not using non-volatile EEPROM or EPROM based operating system and application software shall be acceptable only if each controller is equipped with 120 hours of rechargeable battery backup and low battery level alarm indication at the associated space temperature sensor and FEPC.
2. The VAV Controller (MC) shall be capable of having its standard and custom software, point configuration files, other data files, set-points and parameters, uploaded to the FEPC for storage purposes. Any changes made to a MC can be stored to disk at the FEPC. The FEPC can download the above data to the MC to which it belongs (when replacement of a MC is necessary, the hardware is replaced, and then the specific software for that MC is transmitted from the FEPC to the MC to make it operational). These functions can be performed from any location served by the interconnecting data bus. The POT shall be capable of being connected to the data communications bus via telephone-type connectors at any MC or MC room temperature sensor.
3. All modifications to set-points, parameters, etc., shall be made electronically via a portable operators terminal, and FEPC. The Portable Operator Terminal (POT) shall connect into the system via a port at the space temperature sensor to display and change temperature and air flow setpoints. When accessing the controller from the space sensor or bus-direct, the POT
   shall communicate in a non-interfering, mutually exclusive manner with peer-to-peer controller and host data transmission.
4. Each VAV Controller (MC) shall be equipped with standard pre-installed control programs for such applications as VAV box control valve. These programs are resident in every MC. Any MC can be configured and set up to operate terminal. Controllers without such pre-installed programs are unacceptable.
5. Each MC shall also be able to utilize custom DDC programs to meet the control strategies called for in the sequence of operation.
6. A minimum of 16 bit sensing resolution shall be employed for all sensors.
7. MC shall be provided with standard pre-written and tested step-by-step air balancing procedure. The air distribution system balance contractor shall be able to balance all VAV boxes with MC's by the use of a portable operators terminal and specific menu-prompted balancing software. Proof of existence of such software, such as an operators guide, shall be included with system submittals.
8. To maximize stability of the controls on all mechanical systems, end-to-end time for any control loop (i.e., temperature sensing input to controller output via the MC), regardless of how sophisticated, shall be a maximum of 2 seconds.

2.7 INPUT AND OUTPUT SENSORS AND DEVICES

A. General: Input and output sensors and devices shall be closely matched to the requirements of the DDCP and MC for accurate, responsive, noise free signal input and output. Control input sensitivity shall be matched to the control loop gain requirements for precise and responsive control. In no case shall computer inputs be derived from pneumatic sensors nor shall thermocouples or thermistors be used.

1. Temperature Sensors: Temperature sensors shall be Resistance Temperature Detector (RTD) type of 1000 ohm nickel or 1000 ohm platinum.

   a. Space Temperature Sensors: Provide with blank institutional type locking satin chrome metal covers. Accuracy shall be plus or minus 0.5 deg F.
   b. Duct temperature sensors: Rigid stem or averaging type as specified in the sequence of operation. Accuracy shall be plus or minus 0.5 deg F.
   c. Water Temperature Sensors: Provide with a separable, copper, monel or stainless steel well. Accuracy shall be plus or minus 0.5 deg F.
   d. Freeze Protection Thermostat: Provide with manual reset and an adjustable setpoint between 32 and 55 F. Thermostat shall include sensor that responds to lowest temperature sensed in any one foot segment of the element. At least one foot of sensing element shall be provided per square foot of coil. Install sensor as per the manufacturer's recommendations.

2. Space Relative Humidity Sensors: Relative humidity sensors shall be bulk polymer capacitive type with 20 to 95 percent relative humidity range. Operating range of the sensor shall be 32 to 140 degrees F. Temperature effect shall be less than 0.12 percent per degree F. Accuracy shall be plus or minus 3 percent in the 20 to 95 percent range. Supply voltage shall be 24 to 30 VDC. The sensor response time constant shall be 120 seconds or less.
3. Duct Relative Humidity Sensors: Relative humidity sensors shall be bulk polymer type with 20 to 95 percent relative humidity range with protective filter. Sensor shall be provided with housing for duct mounting. Operating range of the sensor shall be 0 to 170 degrees F. Temperature effect shall be less than 0.04 percent per degree F. Accuracy shall be plus or minus 2 percent in the 20 to 90 percent range. Supply voltage shall be 24 to 35 VDC. The sensor response time constant shall be 15 seconds or less.
4. Differential Pressure Transmitter: The differential pressure transmitter shall be capable of measuring differential pressures from 0 to 250 psig and shall be calibrated for 0-100 psig. The output signal shall be transmitted in an analog 4-20 mA format with an accuracy of plus or minus 0.5 percent of the calibrated span. The transmitter shall have a local span

and zero adjustment and 3-valve manifold to allow for field calibration. Transmitter shall be capable of withstanding both differential and static pressures of up to 250 psig.

5. Equipment Operation Sensors:

   a. Status Inputs for Fans: UL Listed Differential-pressure switch piped across fan with adjustable set point and a range of 0 to 5 inches wg (0 to 1243 Pa) with maximum pressure rating of at least 10 inches wg. For fractional horsepower, non-ducted fans or fans where differential pressure switches shall give unreliable results, properly adjusted UL listed current operated switches may be used.
   b. Humidifier Air Flow Switch: UL Listed Differential-pressure with adjustable set point and a range of 0 to 5 inches wg (0 to 1243 Pa) with maximum pressure rating of at least 10 inches wg.
   c. Filter Alarm: Differential pressure switch piped across filter with adjustable set point and a range of 0 to 5 inches wg, with maximum pressure rating of at least 10 inches wg.
   d. Static Pressure Safety Switches: Static pressure safety switches shall be UL listed, adjustable set point, manual reset and differential pressure type. Switches shall be piped to protect the duct from over-pressurization. Switch shall be single pole double throw (SPDT) and shall be compatible with the DDCP. Maximum pressure rating shall be at least 10 inches wg.

2.8 DAMPERS

A. Automatic control dampers: Provide opposed blade dampers for modulating service and parallel blade dampers for 2-position service. Frames shall be constructed of 13 gage galvanized sheet metal with provisions for duct mounting. Damper blades shall be fabricated from two corrugated sheets of 22 gage galvanized sheet metal spot welded together or from a single 16 gage sheet. Damper blades shall not exceed 8" in width or 48" in length and shall include replaceable PVC coated polyester or santoprene blade edge seals and flexible metal top, bottom, and side seals. Blade shafts shall be 3/8" minimum, zinc plated steel with nylon or oil impregnated, sintered bronze bearings. Damper linkage shall be out of the airstream, concealed in the frame. Dampers shall be rated for; minimum 2000 fpm air velocity at 2.5" static pressure; damper leakage not exceeding 0.35 percent of total CFM (7.0 CFM/sq. ft.) based on 2000 fpm and one inch static pressure when tested per AMCA Publication 500; and temperature range of minus 25 to 180 deg F. Submit leakage and flow characteristics data including actuator torque requirement with shop drawings.

   1. Damper dimensions: Some of the ducts have internal sound lining and the dimensions shown on the drawings are the clear inside dimensions. Coordinate the damper dimensions with the sheet metal installer, to assure that the dampers will fit properly.

B. Damper actuator: Provide electric type, direct shaft mount damper actuators with bracket arrangement for location outside of the air stream Actuators shall provide at least 125 percent of the required torque to effectively operate the damper. Actuator drive time for 90 degrees rotation shall be 70 seconds maximum. Actuators shall be normally open, normally closed, or fail in position as required to obtain the operation as described in the Sequence of Operation or as shown on the DDCP point function schedule. Normally open and normally closed dampers shall return to their normal position in the event of a power failure to the actuator. Provide auxiliary switches, rated as required, to provide specified sequence of operation. Provide transformers, and accessories as required. Actuators requiring linkages, crank arms, connecting rods, or ball joints are not acceptable.

2.9 CONTROL VALVES

A. General: Factory fabricated, of type, body material, and pressure class indicated. Where type or body material is not indicated, make selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature rating of piping system.

B. Characterized Control Ball Valves:

1. Up to and including 2 Inches: Nickel-plated forged brass body, valve trim shall utilize stainless steel ball and stem, fiberglass reinforced Teflon PTFE seats with O-rings, 2 EPDM O-rings packing.
2. Hydronic Systems:

   a. Flow Characterizing Disc: A flow characterizing disc, made of Tefzel Teflon shall be installed in the inlet of 2-way characterized control ball valves. Standard ball valves without this feature are not acceptable.
   b. Pressure Rating: Service at 400 psi and 212°F.
   c. Close Off Pressure: 200 psi
   d. Rangeability: 500:1
   e. Sizing: 5-psi maximum pressure drop at design flow rate.
   f. Flow Characteristics: 2-way valves shall have equal port percentage characteristics.

C. Globe Pattern:

1. Over 2 Inches: Iron body, bronze trim, 316 stainless steel rising stem, bronze plug-type disc, flanged ends, renewable bronze seat and disc, TFE V-ring packing
2. Hydronic Systems:

   a. Pressure Rating: Service at 125 psi WSP and 250°F, ANSI Class 125.
   b. Internal Construction: Replaceable plugs and seats of stainless steel or bronze.

1. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

c. Rangeability: 500:1
d. Sizing: 5-psi maximum pressure drop at design flow rate.
e. Flow Characteristics: 2-way valves shall have equal percentage characteristics.

D. Valve actuator: Provide electric valve actuators which are two position or modulating as required by the Sequence of Operation. Actuators shall be of ample capacity to handle the required load under all conditions and as a minimum shall close valves against pump shutoff head pressure of 55 psi. Unless otherwise indicated, valves shall be arranged to return to the normal (fail-safe) position in the event of a power failure to the actuator.

2.10 RELAYS

A. General: Provide relays with LED relay coil status indicator. Rated coil voltage shall match the application. Contacts shall be DPDT rated for 10 amps resistive at 120 VAC. Panel mounted relays shall be plug-in blade type, with surface or snap track mounted relay bases with screw terminals. Field mounted relays shall be installed in an enclosure and provided with either screw terminals or pigtails. If controlled device does not include a Hand-Off-Auto switch, provide Hand-Off-Auto switch as part of relay.

2.11 FILTER GAGES

A. General: Provide differential pressure sensing device to sense the pressure drop across each air handling unit filter bank and separate filter banks as scheduled. Furnish gages with 0 to 4 inch w.c. range, 0.1 inch minor divisions, plus or minus 3 percent accuracy, adjustable signal flag, and 5 inch diameter case. Surface mount gages on unit or ductwork near filter bank with high and low pressure connections installed according to manufacturer's recommendations. Know acceptable source: Dwyer Series 2004-AF Magnehelic gages.

2.12 DUCT SMOKE DETECTORS

A. Duct smoke detectors are specified in Section 13850 "Fire Alarm and Detection Systems." Coordinate installation of duct smoke detectors with fire alarm and detection system work to provide the specified sequence of operation, and comply with UL 268A requirements.

2.13 AIR FLOW CONTROLS

A. Static pressure transmitter.- Provide electronic static pressure transmitter which shall receive pressure signals from a duct mounted Static Pressure Measuring Station (SPMS). The

transmitter shall amplify and scale the sensed static pressure and produce an electronic output which is linear and proportional to the sensed pressure. The outputs shall be electrically isolated from the power input and shall be directly compatible with the DDCP. The transmitter shall contain an integral 4-digit Light Emitting Diode (LED) display which provides a continuous indication of the sensed static pressure. The transmitters shall be remotely mounted on the side of the SPMS. The transmitter shall not be affected by direction of mounting, altitude, or external vibrations. The housing for the transmitter shall be NEMA 1. The pressure transmitters shall be factory calibrated and include an adjustable zero and span. Known acceptable source: Air Monitor Corporation Veltron. Each transmitter shall include the following:

1. Adjustable span: The static pressure transmitter span shall not exceed 1.5 times maximum pressure for which the transmitter shall operate. Provide transmitter with one of the following standard ranges:

    a. 0 to 1 inch w.c.
    b. 0 to 2 inches w.c.
    c. 0 to 3 inches w.c.
    d. 0 to 4 inches w.c.

2. Calibrated accuracy: plus or minus 0.25 percent of span.
3. Repeatability: 0.15 percent of span.
4. Hysteresis and dead band: Less than 0.2 percent of span.
5. Linearity: plus or minus 0.2 percent of span.
6. Response time: 0.5 second for 98 percent of full span step.
7. Temperature compensation: Less than 0.005 percent output shift per degree F. temperature change at full span, 0 to 140 F. range.
8. Supply power: 24 volt ac/17-40 volt dc, automatic selection, 4 wire.
9. Display: 4 digit, 0.5 inch high, LED display, scaled in inches w.c.
10. Output signal: 4 to 20 mADC, 0 to 10 volt dc or 0 to 5 volt dc (selection to be compatible with DDCS).

B. Air flow volume transmitter.- Provide electronic velocity pressure transmitter/square root extractor/multiplier which shall receive total and static pressure input signals from a duct mounted Air Flow Measuring Station (AFMS). The transmitter/square root extractor/multiplier shall extract, amplify and scale the velocity pressure and produce an electronic output which is linear and proportional to the duct air flow rate (CFM). The outputs shall be electrically isolated from the power input and shall be directly compatible with the DDCP. The transmitter shall contain an integral 4-digit Light Emitting Diode (LED) display which provides a continuous indication of the sensed air flow (CFM). The transmitters shall be remotely mounted on the

side of the AFMS. The transmitter shall not be affected by direction of mounting, altitude, or external vibrations. The housing for the electrical components shall be NEMA 1. The pressure transmitters shall be factory calibrated and include an adjustable zero and span. Known acceptable source: Air Monitor Corporation Veltron. Each transmitter shall include the following:

1. Adjustable span: The velocity pressure transmitter span shall not exceed 1.5 times the maximum pressure for which the transmitter shall operate. Select the transmitter with one of the following standard ranges:

    a. 0.1 inch w.c. = 1,266 FPM
    b. 0.25 inch w.c. = 2,003 FPM
    c. 0.5 inch w.c. = 2,832 FPM
    d. 1.0 inch w.c. = 4,005 FPM

2. Calibrated accuracy: plus or minus 0.25 percent of span.
3. Repeatability: 0.15 percent of span.
4. Hysteresis and dead band: Less than 0.2 percent of span.
5. Linearity: plus or minus 0.2 percent of span.
6. Response time: 0.5 second for 98 percent of full span step
7. Temperature compensation: Less than 0.005 percent output shift per F. temperature change at full span, 0 to 140 F. range.
8. Supply power: 24 volt ac/17-40 volt dc, automatic selection, 4 wire.
9. Display: 4 digit, 0.5 inch high, LED display, scaled in air volume (CFM).
10. Output signal: 4 to 20 mA DC, 0 to 10 volt dc or 0 to 5 volt dc (selection to be compatible with DDCS).

C. Static Pressure Measuring Station (SPMS).- Where indicated on the plans, provide an SPMS to continuously monitor the supply static pressures. Known acceptable source: Air Monitor Corporation VOLU-probe/VS Air Measuring Station. The SPMS shall include the following features:

1. The sound level within the duct shall not be amplified nor shall additional sound be generated by the static pressure measuring station.
2. Each station shall be of all metal construction, and shall consist of a 14 gage galvanized steel casing with 90E connecting flanges, fabricated to the duct size. Each station shall contain multiple airflow traverse probes interconnected by metal tubing to produce a highly accurate measurement of the ducted flow rate.
3. Each airflow traverse probe mounted within the station shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of

these sensors provided in each station shall comply with the ASHRAE standards for duct traversing. The flow sensors shall not protrude beyond the surface of each probe, and shall be the offset type for static pressure and chamfered impact type for total pressure measurement.

4. Each station shall produce a steady, non-pulsating flow signal without the need for a correction factor or calibration.
5. Each station shall be capable of measuring the total airflow (through the station) to within 2% of actual flow.
6. The static pressure measuring stations and the static pressure transmitters shall be standard products of one firm; product mix is not acceptable. The components of the system shall be specifically designed to interface directly with each of the other system components and the DDCP. All components shall be factory calibrated for the specific conditions under which they shall perform on this project.
7. Installation of the static pressure measuring stations shall be as specified under Section 15891. Installation of the transmitters, conduit and wiring shall be by the control system installer. All work shall be done according to manufacturer's recommendations.

D. Air Flow Measuring Station (AFMS).- Where indicated on the plans, provide an AFMS to continuously monitor the supply and outdoor air volumes. Known acceptable source: Air Monitor Corporation FAN-E Air Measuring Station. The AFMS shall include the following features:

1. An air flow straightening section manufactured of non-ferrous 3/8 inch honeycomb material which is fastened to the casing in such a way to withstand velocity flows up to 4000 fpm. The maximum allowable pressure loss through the unit is 0.065 inch wg at 1000 fpm, or 0.26 inch wg at 2000 fpm.
2. The sound level within the duct shall not be amplified nor shall additional sound be generated by the air flow measuring station. The unit shall have a self-generated sound rating of less than NC 40.
3. Each unit shall be capable of measuring the air flow rate with an accuracy of two percent as determined by USGSA certification tests in an independent laboratory.
4. Air flow measuring stations shall be a combination of multi-port self-averaging total pressure and static pressure probes with a minimum of one sensing point for each 36 square inches of unit measuring area. An equal area symmetrical averaging process shall be used to assure accuracy.
5. Welded casings shall be of 14 gage galvanized steel and shall be provided with 90 degree connecting flanges. The air flow measuring station shall be selected to match the free area of the duct size in which it is located and shall be so located to minimize the effect of flowing turbulence. The casing shall be long enough to contain the probes and flow straightening components.

6. An identification label shall be placed on each station casing listing model number, size, area, and specified airflow capacity.
7. The air flow measuring stations and the velocity pressure transmitter/square root extractor/multiplier shall be standard products of one firm; product mix is not acceptable. The components of the system shall be specifically designed to interface directly with each of the other system components and the DDCP. All components shall be factory calibrated for the specific conditions under which they shall perform on this project.
8. Installation of the air flow measuring stations shall be as specified under Section 15891. Installation of the transmitters, conduit and wiring shall be by the control system installer. All work shall be done according to manufacturer's recommendations.

2.14 WATER LEAK DETECTION

A. General: Install new leak detection system in the Control Wing Attic into the Automation Wing Attic to detect leaks in the drip pan below the new and existing hot and chilled water piping above the Control Room, and in the drip pans below the new humidifiers in the Automation Wing Attic. The system shall be capable of detecting the presence of water (40 to 210 F) along the length of the new cable as well as the existing cable. Upon detection of water, the system shall sound an alarm and pin point the location of the leak in a display on the new leak detection system panel. A new DDCP alarm input will activate an alarm signal at the FEPC.

1. Provide water leak detection sensing cable in the new drip pan below the entire length of new pipes located above the Control Room in the attic. Connect the new sensing cable to the existing sensing cable currently installed in the adjacent existing drip pan, using quick-connect-type connectors installed on the cable ends.
2. Provide a leak detection sensing cable in each of the new humidifier drip pans in the Automation Wing Attic. Connect the sensing cable in the humidifier drip pans to the sensing cable above the Control Room with system jumper cables using quick-connect-type connectors installed on the cable ends.

B. Water Sensing Cable: As a minimum, the water sensing cable shall consist of two sensor wires, a continuity monitor wire, and an insulated signal return wire. The sensor wires shall be jacketed by a conductive polymer to protect the conductors from corrosion. The sensor wires, continuity wire, and signal wire shall be covered by an abrasion resistant protective braid. The cable shall be provided in modular lengths of 3, 10, 25 or 50 feet with factory installed male/female quick-connect-type connectors on each end. The cable shall be flexible and carry not more than 24 VDC under normal operating conditions.

C. Jumper Cable: The jumper cable shall consist of four wires in an overall insulated jacket to provide conductivity between the four wires in the segments of the water sensing cable. The

cable shall be provided in modular lengths of 3, 10, 25 or 50 feet with factory installed male/female quick-connect-type connectors on each end that are compatible with the connectors on the water sensing cable.

D. System Map: Install new system map adjacent to the new leak detection system panel with a new wall mounted floor plan location map to show the layout of the leak detection cable in both the Control Wing and the Automation Wing. The map shall show the exact layout of entire new cable system with numerical indications in feet of each 25-foot interval along the cable (i.e., 0 feet, 25 feet, 50 feet, and 75 feet) and at center of each bend. The map shall also show locations and identifications of the control unit, the system map, the pipe drip pan, and the humidifier drip pans. The map shall be drawn at not less than 1/8 inch per foot scale, and it shall be clearly legible and readable. The map shall be installed behind a clear Plexiglas sheet for protection.

2.15 TAGS

A. Tags: Devices shall be permanently labeled with phenolic resin nameplates, black with white lettering, with minimum 1/4 inch lettering. Tag shall include device ID's as shown on as-built documentation and DDCP software identification. Internal and external wires shall also be labeled.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Install equipment as indicated to comply with manufacturer's written instructions.

B. Connect and configure equipment and software to achieve the sequence of operation specified.

C. Verify location of temperature sensors, humidity sensors, and other exposed control sensors with plans and room details before installation. Locate room sensor 60 inches (1524 mm) above floor.

D. Install damper motors on outside of duct.

E. Install labels and nameplates to identify control components according to Section 15050. Devices shall be permanently labeled with phenolic resin nameplates, black with white lettering, with minimum 1/4" lettering. Tag shall include device ID's as shown on as built documentation and DDCS software identification. Internal and external wires shall also be labeled. Submit a complete list of nameplates prior to ordering.

F. Install hydronic instrument wells, valves, and other accessories according to Section 15180.

G. Install control dampers according to Section 15910. Install dampers in accordance with manufacturer's written instructions.

H. Install software in control units and operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation. Computer programs and data shall be compatible with existing DDCS and FEPC. Provide English listing of analog/digital points and alarm messages. Symbols and color convention for graphic data shall be compatible with existing FEPC. Merge existing data with the new data base to form a single building management system.

3.2 ELECTRICAL INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 16 Section 16100 "Raceways, Boxes, and Cabinets."

B. Install building wire and cable according to Section 16120.

1. Install wire and cable in raceways.
2. Fasten flexible conductors, bridging cabinets and doors, neatly along hinge side; protect against abrasion. Tie and support conductors neatly.
3. Number-code or color-code conductors, except local individual room controls, for future identification and servicing of control system.

C. Connect electrical components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

D. Provide HAND-OFF-AUTO selector switches to override automatic interlock controls when switch is in HAND position, except for safety interlocks such as smoke detectors or fire alarm interlocks.

3.3 COMMISSIONING

A. Manufacturer's Field Services: Provide the services of a factory-authorized service representative to start control systems.

1. Verify that equipment installation complies with contract documents, NEC, and manufacturer's written installation requirements. Correct deficiencies before proceeding.
2. Update existing DDCPs and FEPC to latest software revision available. Confirm proper operation before proceeding.
3. Install DDCP, MC, and FEPC software and data for new equipment.
4. Test and adjust controls and safeties.
5. Replace damaged or malfunctioning controls and equipment.
6. Start, test, and adjust control systems.
7. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified and to provide safe, efficient operation.

3.4 TRAINING

A. General: Skilled and efficient use of the system requires operators trained to a level of proficiency that allows the Government to be independent from the DDCS supplier and assures the Government that the capability of the DDCS can be used to operate the facility safely and efficiently. Government support personnel shall be trained on the system software prior to the completion of the system installation. Submit factory course description with outline, and conduct the sessions with factory instructors and training material after commissioning is complete and before acceptance of the system. Equipment installers are not acceptable instructors. Provide the following training:

B. Operator training: Emphasis shall be on maintenance training, which shall provide in-depth knowledge on how to conduct complete troubleshooting, maintenance and repair of the installed equipment. Training shall include both diagnostics software and hardware maintenance. Provide review of menu driven operator's training of data display, alarm and status descriptors, data requesting, execution of commands, insertion and deletion of a point and development of software maintenance. Preventive maintenance training shall also be provided to determine software, firmware, or hardware failures.

1. Provide two shifts of operator training consisting of two eight-hour sessions and then one eight-hour session two weeks later using the same material for each shift and encompassing:

    a. Installation, wiring, calibration and troubleshooting of sensors, MCs, DDCPs, and control devices;
    b. Repair and replacement of sensors, MCs, DDCPs, and control devices;
    c. Preventative maintenance;
    d. Sequence of operation review;

e. Sign on - Sign off;
f. Selection of all displays and reports;
g. Commanding of points, keyboard and mouse mode;
h. Modifying English text;
i. Use of all dialogue boxes and menus;
j. Modifying warning limits, alarm limits and start and stop times;
k. System initialization;
l. Download and initialization of remote panels;
m. Purge and dump of historical data;
m. Use of a portable operators terminal; and
n. Password modification.

2. Supervisor training: Provide an additional eight hours of supervisor training encompassing:

a. Password assignment and modification;
b. Operator assignment and modification;
c. Operator authority assignment and modification;
d. Point disable and enable;
e. Terminal and data segregation and modification;
f. Use of a portable operators terminal; and
g. Use of spreadsheet package with system data.

3. Programming training: Provide two additional eight hours of programming training encompassing:

a. Software review of Sequence of Operation and flowcharts;
b. Modification of control programs;
c. Add-Delete-Modify data points;
d. Use of diagnostics;
e. System maintenance procedures;
f. Review of initialization;
g. Upload and download and off line archiving of all system software.
h. Programmer training shall be for two Government personnel and shall be scheduled by the COR with two weeks advance notice anytime during the warranty period; and
i. Graphic creation.

4. Training aids: Provide all training aids, equipment and training manuals. Provide one copy of the training manual for each student. Submit materials for Government approval.

5. Student education level: The training for the various courses shall be structured for electrical/electronic technicians with experience in operating computers, but little experience in programming. The students education level shall be high school plus approximately two years technical training in math, sciences, and electrical and mechanical equipment.
6. Follow-on training: Provide a total of 48 hours of additional training during the six months after the acceptance of the control system. The training is to cover system operation and maintenance for the FAA technicians who operate the system. The training shall be scheduled with DDCS Supervisor at an approximate rate of 8 hours per month.

3.5 FIELD QUALITY CONTROL

A. Test Plan: Submit test plan at least 60 calendar days prior to conducting the acceptance tests. Develop a detailed testing plan which consists of step by step procedures for entering nominal values into the system to simulate environmental conditions to be expected. Each test shall fully demonstrate the system operation capability as required by section 15975 and as described below.

1. Display demonstration: Perform a complete demonstration and readout of the capabilities of monitoring and control system in both textual and graphical format. This demonstration shall include an all points log to validate operation of 100 percent of the data points. Successful demonstration, including installation and training, constitutes a partial acceptance of the delivered system for on line operation. The demonstration shall include the basic operation of 100 percent of the connected points and shall show, in accordance with the I/O summary:

   a. Analog display;
   b. Digital display;
   c. Start/Stop display;
   d. Command of selected start/stop points; and
   e. Selected Set Point Adjustment (SPA) action, both automatically and manually initiated.

2. Functional demonstration: The following functions shall be demonstrated:

   a. Analog alarm and return to normal;
   b. Digital alarm and return to normal;
   c. Start/Stop alarm and return to normal;
   d. Off line memory access, including modification of at least two addressable memory locations;

e. Software driven functions, including energy management application programs, event initiated programs, alarm limits and analog alarm lockout;
f. That operator terminal is capable of full system control;
g. That PPT and POT area capable of local display, adjustment, and control;
h. That single points and groups of points can be added or deleted in the program through keyboard entry;
i. Sequential start up after simulated power interruption;
j. Fail safe operation;
k. Alarms and other functions;
l. Simulated failure of all main equipment and auto transfer to standby;
m Simulated power failure and automatic restarting of main equipment;
n. Simulated failure of DDCPs transmission bus;
o. DDCP failure (annunciate at FEPC); and
p. MC failure (annunciate at FEPC), with controlled devices positioned as required in the fail mode section of the DDCP point function schedule.

3. Operator programming demonstration: The following programming capabilities shall be demonstrated:

a. Assigning of high and low analog alarm limits;
b. Modifying analog alarm value;
c. Displaying group condition showing group detected, point within group off normal, ground fault and AC power off;
d. Modifying time based program by setting and resetting time assignment;
e. Dumping and reloading data;
f. Adding a point (the point type shall be selected by the COR at time of acceptance);
g. Deleting a point;
h. Adding a new group of points; and
i. Uploading and downloading of MC configuration programs.

4. Validation: Completely check out, calibrate and test connected hardware and software to insure that the system performs in accordance with the specified requirements and approved sequences of operation. Validation shall be witnessed by COR.

a. Running each specified report;
b. Displaying and demonstrating each data entry to show site specific customizing capability and demonstrating parameter changes;
c. Step through penetration tree, displaying graphics, demonstrating dynamic update and direct access to graphics;
d. Executing digital and analog commands in graphic mode;

e. Demonstrating DDC loop precision and stability through trend logs of inputs and outputs (6 loops minimum) by continuous operation of 7 days testing;
f. Demonstrating VAV box MC operation including both on-line and stand alone performance;
g. Demonstrating EMS performance through trend logs and command trace;
h. Demonstrating scan, update, and alarm responsiveness;
i. Demonstrating spreadsheet and curve plot software and its integration with the database;
j. Demonstrating on line user guide and help function and mail facility;
k. Demonstrating digital system configuration graphics with interactive upline and downline load, and demonstrating specified diagnostics;
l. Demonstrating multitasking by showing dynamic curve plot and graphic construction operating simultaneously through split screen;
m. Demonstrating class programming with point options of beep duration, beep rate, alarm archiving and color banding;
n. Demonstrate DDCP stand alone execution, remote control interface, upload and download data from remote controller, and MS DOS compatibility;
o. Demonstrate MC stand alone execution, remote control interface, upload and download data from remote controller;
p. Time and event application control: Demonstrate that the system is capable of start/stop of controlled devices based on time and date setting, occupancy schedules, holiday schedules, activity defined schedules, lead/lag time and schedules changes, and rotational schedules; and
q. Network strategies: A trend on panel, installed under this project, shall be set up for a point from an existing panel. This point shall also be trended in its own panel for the same intervals. Comparison of the two trends shall indicate if communication problems occurred during the 7 days testing period. Provide a historical communication error summary for the 7 day period as an alternative.

B. Testing: Perform complete tests, as indicated. Schedule test date with COR and confirm date in writing at least ten working days prior to test. The written test date confirmation shall identify changed conditions which may affect the test results. Provide equipment and personnel required to perform the test. Perform tests of the DDCS, in accordance with the approved test plan, in presence of the COR. The test shall not cause facility interruption in any manner and shall be conducted during “off-normal” hours as described under Equipment Shutdown in Part 1 of this section.

C. Installation inspection report.- Upon completion of tests, a list shall be provided by the COR, showing each outstanding item. The Contractor shall provide a schedule detailing items to be corrected and date for completion. As each item is approved, an appropriate notation shall be

entered at the time of correction on the inspection report, with counter signature of the COR and date. A copy of this report shall be provided to the COR. If the system fails acceptance tests, the Contractor shall operate his system off line during corrective procedures.

3.6 ACCEPTANCE

A. As Built documentation: Submit complete set of as built data which shall identify the equipment supplied and the interconnecting wiring along with identification of components by part number or by ordering number. Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences. Data shall also include final setpoints, alarm limits, time schedules, and other DDCP software information specific to this installation.

1. DDCP Database: Maintain diskette copies of data files and application software for reload use in the event of a system crash or memory failure. Deliver one copy to the COR during training session, and archive one copy in a local software vault to be provided by the control manufacturer and located within 40 miles of the ARTCC.
2. Design drawings: Deliver one copy of CAD generated system design drawings in DGN format to the COR during training session, and archive one copy in a local software vault to be provided by the control manufacturer and located within 40 miles of the ARTCC.

B. Software, firmware and hardware documentation rights: The system described shall be used to control environmental parameters at Air Route Traffic Control Centers. As such, it is essential that the Government have full and complete rights to system software, and to system firmware and hardware documentation supplied for this project. The Government shall have the right to reproduce (for internal use), copy, alter, use (within the scope of this project) data and software submitted. In return for this right the Government agrees to maintain this data in a reasonably secure manner and agrees not to divulge the data to competitors or use the data for alternate purposes. The DDCP manufacturer shall be required to license the Government to use the FEPC, MC, and DDCP software.

C. Acceptance: The acceptance date of the system shall be that date the COR and the Contractor jointly agree that the system meets the requirements of this specification. This date shall be the effective date of the start of the first year maintenance contract and shall constitute formal acceptance by the FAA at the facility.

3.7 MAINTENANCE SERVICE

A. First year maintenance service: Provide first year maintenance including, but not limited to, materials, labor, and freight. A single source at the contractors facility shall be identified for

first year maintenance, adjustments, and calibration type items. Failures under first year maintenance shall be corrected by the contractor at his expense. Such occurrences shall not void acceptance. However, the DDCP contractor shall be responsible to remedy such items before acceptance is complete. Appropriate logs, schedules, and reports shall be maintained to reflect those items and their redress. First year maintenance service shall extend for a period of one year after system acceptance and shall include the following provisions:

1. Establish and maintain a telephone line which may be used by field facilities to obtain factory support of the installed system. The telephone number shall be made available to the Government facility at the time of installation. The telephone shall be staffed by an on-call factory trained equipment specialist and programmer. The telephone shall be answered during normal plant hours. During nights, weekends, and holidays, an answering machine shall be provided to receive Government trouble calls. Trouble calls shall be returned by the factory within 14 hours of receipt of the call on night, weekend, and holiday calls, and within two hours if the call is received during normal plant hours.
2. Ship LRUs and requested parts upon request by the Government facility requiring first year maintenance parts and assistance, within three hours during normal plant hours and within 15 hours during nights, holidays, and weekends. Shipping costs to the Government facility shall be borne by the contractor. Shipping shall be UPS or similar fast door-to-door service. Factory shipments shall be addressed to the Environmental Support Unit.
3. Repair all returned parts at the contractors expense. The only exception is for neglect or abuse such as damage by liquids or breakage or power anomalies.
4. Contractor first year maintenance support applies to software as well as equipment.
5. Government maintenance technicians shall perform required preventative maintenance tasks in accordance with periodic maintenance tasks and procedures specified in the Contractors periodic maintenance requirements handbook.
6. Provide to the COR a local existing commercial source (within the local metropolitan commuting area) where parts, LRUs and circuit boards, and trained technical support can be obtained. The Government at its discretion has the right to procure parts and service on a local basis to restore the system to an operating configuration on an emergency basis and such action shall not void the guarantees. Costs for local support shall be borne by the Government.

3.8 SOFTWARE SUPPORT SERVICE

A. First year software support service: Up to 100 hours of software support shall be provided by a technical representative of the DDCP manufacturer, during the first six months following the final acceptance of the control system. The software support shall include software changes to fine tune the system and to support changes to the Sequence of Operation for the DDCPs

installed under this contract, as well as any DDCPs installed under previous contracts. The software support shall be scheduled by the DDCS supervisor on an as needed basis.

END OF SECTION 15975

SECTION 15990 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

   a. Variable-volume air systems.

2. Hydronic Piping Systems:

   a. Variable-flow systems.

3. HVAC equipment quantitative-performance settings.

4. Sound and Vibration Systems.
5. Reporting results of activities and procedures specified in this Section.

1.2 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

M. TAB: Testing, adjusting, and balancing.

N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

O. Test: A procedure to determine quantitative performance of systems or equipment.

P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 6 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Strategies and Procedures Plan: After complete review of the Contract Documents and within 60 days from Contractor's Notice to Proceed, submit 6 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project. Identify issues and concerns found while reviewing contract documents.

C. Draft reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit two complete sets of draft reports. Only one complete set of draft reports will be returned.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. Test and Balance Engineer's Qualifications: A Licensed Professional Engineer (either on the TAB agencies' staff or and independent consultant), registered in the State of Washington, and having at least 5-years of successful testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project

C. TAB Conference: Meet with COTR on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.
b. The Contract Documents examination report.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

D. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

E. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems," NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing."

F. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

G. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 PROJECT CONDITIONS

A. Full FAA Occupancy: FAA will occupy the site and portions of the building during entire TAB period. Cooperate with FAA during TAB operations to minimize conflicts with FAA's operations.

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

A. Provide warranty in accordance with one of the following:

B. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

C. Special Guarantee: Provide a guarantee on NEBB forms stating that 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.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation. Identify where additional balancing devices are required.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine plenum ceilings used for return air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

L. Examine strainers for clean screens and proper perforations.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine equipment for installation and for properly operating safety interlocks and controls.

P. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, and mixing boxes.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems," NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and this Section. The procedures shall be clearly identified in the TAB plan.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling unit components.

K. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. General: Refer to Section 15975, "Electronic and Direct Digital Controls" for air-handling unit sequence of operation. The air-handling unit has a sequence of operation that is similar to the sequence of operation for a VAV box. The unit airflow will be reset between minimum and maximum airflow rates based on the space temperature. Lower airflow rates are used for heating. Full airflow is required for summer cooling.

B. Variable-Air-Volume System:

1. Measure total system airflow. Adjust to within indicated airflow.
2. Measure and adjusted dampers to provide required minimum outdoor air. Coordinate damper settings with automatic controls.

3. Measure room pressure with respect to outdoors. If an economizer is provided, measure airflows with minimum outdoor air and again with maximum outdoor air and adjust relief air damper as required to maintain a slight positive pressure.
4. Set air-handling unit at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflows.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
    b. At minimum supply fan airflow, adjust dampers to ensure that required minimum outdoor air is provided. Coordinate damper settings with automatic controls.

5. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets.
6. Record the final fan performance data.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

A. Central Plant Equipment: Prior to start of hydronic system balancing, coordinate with COTR to ensure that central plant equipment is operated in a consistent manner that will not adversely affect the system balancing. Ensure that adequate boilers, chillers, and pumps are in operation for all operational equipment within the facility.

1. Verify operating status of central plant boilers, chillers, and pumps. Identify units in operation. Chiller plant has 4 chillers and 4 chilled water pumps. Boiler plant has 3 boilers and 3 pumps. Check pump model numbers and obtain pump curve from manufacturer or from FAA if they have information available.
2. Measure supply and return water temperature for boilers and chillers.

3. Measure flow rates of pumps.
4. Measure supply and return water pressures.
5. Balancing of central plant pumps, boilers and chillers is not required.

B. Set calibrated balancing valves, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

F. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems. Where available pump capacity is less than total flow requirements, proportional balancing must be performed.

3.9 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.
8. Variable Frequency Drive speed/hertz at design airflow rate.
9. Variable Frequency Drive speed/hertz at minimum airflow rate.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

3.11 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of one eight-hour days, on first and second floors, to prove correctness of final temperature settings.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.12 TEMPERATURE-CONTROL VERIFICATION

A. Coordinate with commissioning work required to verify temperature control system operation.

3.13 TESTING FOR SOUND AND VIBRATION

A. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

B. Perform noise testing in occupied areas to insure that the HVAC System meets the NC 35 requirement.

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: minus 5 to plus 10 percent.
2. Air Outlets and Inlets: minus 5 to plus 10 percent.
3. Heating-Water Flow Rate: minus 5 to plus 10 percent.
4. Cooling-Water Flow Rate: minus 5 to plus 10 percent.

3.15 REPORTING

A. Strategies and Procedures Plan: After complete review of the Contract Documents and within 60 days from Contractor's Notice to Proceed, submit 6 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report

forms intended for use on this Project. Identify issues and concerns found while reviewing contract documents.

B. Draft reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Include a list of deficiencies and problems found in systems being tested and balanced. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.

3.16 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the Licensed Professional Testing and Balancing Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

a. Indicated versus final performance.
b. Notable characteristics of systems.
c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Settings for supply-air, static-pressure controller.
    g. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Sheave dimensions, center-to-center, and amount of adjustments in inches .
    j. Number of belts, make, and size.
    k. Number of filters, type, and size.

2. Motor Data:

    a. Make and frame type and size.
    b. Horsepower and rpm.

c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat coil static-pressure differential in inches wg.
g. Cooling coil static-pressure differential in inches wg.
h. Heating coil static-pressure differential in inches wg.
i. Outside airflow in cfm.
j. Return airflow in cfm.
k. Outside-air damper position.
l. Return-air damper position.

G. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outside-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and size.
    e. Manufacturer's serial number.
    f. Arrangement and class.
    g. Sheave make, size in inches, and bore.
    h. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. Motor Data:

    a. Make and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
    g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and air-handling unit number.
    b. Location and zone.
    c. Traverse air temperature in deg F.
    d. Duct static pressure in inches wg.
    e. Duct size in inches.
    f. Duct area in sq. ft.
    g. Indicated airflow rate in cfm.
    h. Indicated velocity in fpm.
    i. Actual airflow rate in cfm.
    j. Actual average velocity in fpm.
    k. Barometric pressure in psig.

J. System-Coil Reports: For heating coils include the following:

1. Unit Data:

    a. System and air-handling unit identification.
    b. Location and zone.
    c. Room or riser served.
    d. Coil make and size.
    e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

    a. Airflow rate in cfm.
    b. Entering-water temperature in deg F.
    c. Leaving-water temperature in deg F.
    d. Water pressure drop in feet of head or psig.
    e. Entering-air temperature in deg F.
    f. Leaving-air temperature in deg F.

K. Instrument Calibration Reports:

1. Report Data:

    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.17 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:

    a. Measure airflow of at least 10 percent of air outlets.
    b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
    c. Verify that balancing devices are marked with final balance position.
    d. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by COTR
2. TAB firm test and balance engineer shall conduct the inspection in the presence of COTR and commissioning agent.

3. COTR shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.18 DEMONSTRATION AND TRAINING

A. Demonstration and Training: Provide one session, four hours long, to review the TAB report with the maintenance staff. Provide demonstration and training in accordance with Section 01820, “Demonstration and Training.”

END OF SECTION

DIVISION 16

ELECTRICAL SYSTEMS

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. General:

1. Materials and equipment shall comply with all requirements of the contract documents. Materials furnished by the contractor shall be new, the standard products of manufacturers regularly engaged in the production of such materials, and of the manufacturer's latest designs that comply with the specification requirements. If material and equipment requirements conflict, the order of precedence for selection shall be as follows: special contract provision, the contract drawings, this specification; and then in continuing order of precedence, Military Specifications, Federal Specifications, NFPA publications, IEEE standards, UL standards and NEMA standards. Wherever standards have been established by Underwriters' Laboratories, Inc., the material shall bear the UL label.

B. This Section includes the following electrical materials and methods:

1. Supporting devices for electrical components.
2. Electrical demolition.
3. Cutting and patching for electrical construction.
4. Touchup painting.

C. Applicable provisions of this Project include the following:

1. Remove existing electrical system equipment in accordance with demolition drawings and specifications.
2. Provide equipment, wiring devices, and electrical connections required for installation of electrical equipment.
3. Provide indoor, normal and emergency lighting system.
4. Provide raceways and wiring for power and controls.
5. Provide grounding systems.
6. Provide empty conduit system for telephone and data.
7. Provide fire alarm detection system.
8. Provide public address system.
9. Provide seismic bracing.

D. Space requirements: Electrical equipment sizes indicated on the Drawings are generally based on specified manufacturer.

1. Verify that the equipment proposed will fit in the space indicated on the Drawings. Coordinate building dimensions with architectural and structural drawings. Equipment furnished and installed under other Sections of this specification shall be coordinated with electrical equipment installed under this Section.

2. Maintain clearances required by NEC around electrical equipment. Establish the exact location of electrical equipment based on the actual field verified dimensions of equipment furnished.

1.2 REFERENCE STANDARDS

A. General: Comply with the standards in effect as of the date of the Contract Documents as applicable to the extent specified in Division 16. The rules, regulations and reference specifications enumerated in these specifications shall be considered as minimum requirements. Adherence to other standards shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by this specification. Adherence to this specification shall not relieve the Contractor from furnishing and installing higher grades of materials and workmanship when so required by the contract Drawings or special contracts provisions. This specification shall govern when conflicts occur. The documents referenced in Article 1.1, paragraph A, sub-paragraph 1, of this Section.

B. American National Standards Institute (ANSI)

1. A13.1 Scheme for the Identification of Piping Systems.

C. American Society for Testing and Materials (ASTM)

1. A36 Standard Specification for Carbon Structural Steel.
2. A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

D. Federal Aviation Administration (FAA)

1. STD-019e Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities.
2. C1217f Electrical Work, Interior.
3. C1391a Installation and Splicing of Underground Cables.

E. Institute of Electrical and Electronic Engineers (IEEE)

1. 519 Recommended Practices and Requirements for Harmonic Control and Electrical Power Systems.

F. National Electrical Contractors Association (NECA)

1. Standard of Installation

G. National Electrical Manufacturers Association (NEMA)

1. WC 5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
2. WC7 Cross Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

H. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

I. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Description and Requirements for a Nationally Recognized Testing Laboratory (NRTL).

J. Underwriters Laboratories (UL)

1. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.

1.3 SUBMITTALS

A. Product Data for each type of product specified.

B. Shop Drawings detailing fabrication, installation, and location of supports, seismic bracing, and anchorage for electrical items.

C. Project Record Documents: Maintain at the job site a separate set of white prints of the Contract Documents for the purpose of recording the system and dimension changes of those portions of work in which actual construction is significantly at variance with the Contract Documents. The Contractor shall record changes for both GFE and Contractor provided equipment. Upon acceptance of the project, submit documents to the COR, with verification of data accuracy. Mark the Drawings with colored pencil. Prepare the Drawings as the work progresses. Upon completion of work submit Drawings clearly indicating the following:

1. Locations of devices, conduits, equipment and other pertinent items.
2. Schematic and interconnection wiring diagrams of the completed power and control system incorporating the data derived from the equipment shop drawings. The drawings shall be detailed to wire and terminal block numbers, conductor color coding, device designations, locations, and reflect identifications established at the site.

D. Samples of color, lettering style, and other graphic representation required for each identification product for Project.

E. Operation and Maintenance Instructions:

1. Reference Material: Provide three copies of operating and maintenance instructions, equipment service manuals, catalog cuts and illustrations as described herein. The Operations and Maintenance (O&M) data shall be placed in suitable binders for use by maintenance personnel. The material shall include equipment model and serial numbers, performance characteristics, and power and utility requirements. Final acceptance of this equipment is contingent upon submission of required documents to, and approval by, the COR prior to equipment or facility turnover.
2. Minimum Data Required: Operating and maintenance instructions shall contain the following minimum data and shall comply with submittal requirements specified in individual Sections of

the Specifications. Training on the operation and maintenance of special equipment shall be conducted by a certified technician from the manufacturer.

a. Operating instructions shall include illustrations and explanations for controls, initial set points, and startup and shutdown procedures for both normal and emergency conditions.
b. Maintenance instructions shall include periodic inspection and lubrication requirements, and when applicable, equipment performance verification requirements. Include a list of required tools and equipment to maintain the system.
c. Troubleshooting and fault diagnosis data shall list trouble symptoms, instructions necessary to determine cause of trouble and the action required to restore equipment to operating condition.
d. Repair instructions shall include equipment disassembly, repair, replacement, and reassembly. Checkout or test data shall also be provided. Reprogramming instructions shall be provided for equipment having a programmable memory. Repacking instructions shall be provided for sending equipment to the manufacturer or to a repair depot for repairs.
e. A parts list shall be furnished that includes part names and part numbers that are shown on illustrations or tables. The parts list shall identify the actual manufacturer of the part, replacement cost, and shall also contain a notation of identifying products as Commercial grade for common non-special design hardware.
f. The instructions shall contain a list of spare parts recommended by the equipment manufacturer to support the operation of the equipment for a one year time period. Provide names, addresses, and telephone numbers of all service organizations that supply repair parts for the system or systems to be furnished.
g. The O&M data shall include overhaul instructions that are required to return the equipment to full operational capability in the event that the machinery stops working properly.

h. The O&M data shall contain as appropriate, the following:

1) Wiring diagrams
2) Electrical schematics
3) Control diagrams
4) Wire terminal assignments
5) Equipment layouts
6) Record Electrical Drawings, modified to record actual conditions and modifications, including dimensions
7) Approved Shop Drawings

i. After final tests and adjustments have been completed, fully instruct the COR and other personnel, as directed by the COR, in details of operation and maintenance of special equipment, including control system, and fire alarm system, as installed. Submit outline of proposed instruction course, scheduled during a 3 week period, 21 days prior to start, for approval by the COR.

F. Operating Tests: An interim operating and performance test shall be performed for each major equipment item after installation is complete and before the item is placed in service. After mechanical systems have been completely installed and balanced, test each system for proper

operation. Tests shall be conducted in the presence of the COR under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of the systems. Special tests on individual systems are specified under individual sections. Tests shall be scheduled and approved in writing by COR at least 10 working days prior to conducting tests. Contractor shall demonstrate, to the COR's satisfaction, proper operation of control devices by simulating actual operating conditions. Devices tested shall include, but not be limited to, flow and pressure controls, temperature controls, and system interlocks and alarms.

1.4 QUALITY ASSURANCE

A. All materials procured and installed under this specification shall be in accordance with FAA-C-1217f and FAA-STD-019e.

B. Comply with NFPA 70 for components and installation.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

D. Summary: Submit a summary of the Electrical Test Report and Motor Test Report, noting deviations from requirements listed below:

1. Maximum plus or minus five percent variation between nominal system voltage and no load voltage and between no load and full load voltage;
2. Variation between motor average phase current and measured individual phase currents does not exceed the manufacturer's specified limits; and;
3. Maximum plus or minus ten percent variation between average phase current and measured individual phase currents for panel-boards.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate electrical equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.

C. Coordinate installing required supporting devices and other structural components as they are constructed.

D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work.

E. Coordinate connecting electrical service to components furnished under other Sections.

F. Coordinate requirements for access panels and doors where electrical items requiring access are covered by finished surfaces. Access panels and doors are specified in Section 08305 "Access Doors."

G. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.

H. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

I. Interruption of Power: Contractor is advised that this facility includes a fully operational Air Traffic Control Center (ARTCC). The electrical power system is comprised of the types: critical, essential, and building service. Work shall be performed on the three types as indicated on drawings. Unscheduled interruptions of the electrical service may cause aircraft accidents and loss of life. Contractor is advised that failure to establish and maintain proper means and methods during the Work, resulting in accidents or loss of life, may result in charges of criminal negligence.

1. Work requiring a temporary or permanent de-energizing of critical, essential, and building service power systems shall be scheduled and approved in writing by the COR at least 21 calendar days in advance of performance of work.
2. Work may not commence until written authorization is received from the COR.
3. Unscheduled interruptions of power shall not be allowed at any time.
4. Only Government personnel are authorized to energize or de-energize equipment, to operate circuit breakers, switches, or fuses in this facility. Only the utility company shall be authorized to turn on, or turn off, the commercial power to this facility.

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES

A. Provide channel and angle support systems, hangers, anchors, sleeves, brackets, fabricated items, and fasteners to provide secure support from the building structure for electrical components.

1. Material: Steel, except as otherwise indicated, protected from corrosion with zinc coating or with treatment of equivalent corrosion resistance using approved alternative finish or inherent material characteristics.
2. Metal Items for Damp Locations: Hot-dip galvanized steel, except as otherwise indicated.
3. Seismic Zone: All support systems shall be designed and installed to withstand the local code equivalent of UBC Seismic Zone 4 forces.

B. Provide steel channel supports with 9/16-inch diameter holes at a maximum of 8 inches on center, in at least 1 surface.

1. Fittings and accessories to mate and match with channels and from same manufacturer.

C. Raceway Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps or "click"- type hangers.

D. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with welded spiral seams or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:

   a. 3-inch and smaller: 20-gage.
   b. 4-inch to 6-inch: 16-gage.
   c. over 6-inch: 14-gage.

2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

E. Expansion Anchors: Carbon-steel wedge or sleeve type.

F. Toggle Bolts: All-steel spring head type.

G. Powder-Driven Threaded Studs: Not Allowed.

H. Fasteners for plastic-laminated and metal signs: Self-tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat end lock washers.

I. Supplementary Structural Supports: ASTM A 36 steel shapes

1. Supports shall be designed and installed to withstand the local code equivalent of a minimum UBC Seismic Zone 4 force.
2. Provide the installation of supplementary structural supports required for attachment of hangers and other devices supporting electrical equipment and conduits.
3. Members welded to main structural members shall be equal to the specification for the main structural member.
4. Size support members for their actual loads without excessive deflection and with consideration for rigidity under vibration.

2.2 TOUCHUP PAINT

A. For Equipment: Provided by equipment manufacturer and selected to match equipment finish.

B. For Non-equipment Surfaces: Matching type and color of undamaged, existing adjacent finish.

C. For Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION REQUIREMENTS

A. All materials and equipment shall be installed in accordance with the Contract Drawings, and with FAA-C-1217f and FAA-STD-019e.

B. Where manufacturers recommended installation methods conflict with contract requirements, difference shall be resolved by the COR

C. The installation shall be accomplished by skilled workers regularly engaged in this type of work. Where required by local regulation, the workers shall be properly licensed.

D. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated.

E. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated.

F. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

G. Give right of way to raceways and piping systems installed at a required slope.

H. Removal and Relocation of the Existing Work: The Drawings indicate the extent of modifications to existing work. Electrical equipment which is part of, or operates in conjunction with, relocated mechanical equipment shall be disconnected, relocated and reinstalled with mechanical equipment. Equipment and materials indicated to be relocated will be inspected by COR prior to removal. The relocation and reinstallation of mechanical equipment is specified in applicable Mechanical Sections of the Specifications. The work shall be performed with care in order not to damage the existing equipment and materials. Repair or replace equipment and materials damaged. Notify the COR prior to removal of equipment and materials indicated on the Drawings to be removed and relocated.

I. Removal of Polychlorinated Biphenyls (PCB) Contaminated Ballasts: Lighting ballasts used in this facility may contain PCBs as indicated in drawings. PCB contaminated ballasts designated to be removed shall be disposed of in accordance with Section 02070.

3.2 ELECTRICAL SUPPORTING METHODS

A. Damp Locations: Hot-dip galvanized materials or nonmetallic, U-channel system components.

B. Dry Locations: Steel materials.

C. Support Clamps for PVC Raceways: Click-type clamp system.

D. Conform to manufacturer's recommendations for selecting supports.

3.3 INSTALLATION

A. The rules, regulations, and reference documents indicated shall be considered as minimum requirements and shall not relieve the Contractor from furnishing and installing higher grades of materials and workmanship than are specified or when required by the Contract Drawings. Equipment shall be installed in a manner to provide proper working spaces, access, and space for removal of the equipment as required.

B. Contract Drawings: Where the Drawings schematically indicate the work, diagrammatically or otherwise, furnish and install equipment, material, and labor for a complete and proper installation. Ensure that electrical and communications Work is coordinated and compatible with Architectural, Mechanical and Structural Work.

C. Firestopping: Apply to cable and raceway penetrations of fire-rated floor and wall assemblies. Perform firestopping as specified in Section 07270, "Fire-Stopping" to reestablish the original fire-resistance rating of the assembly at the penetration.

D. Fastening: Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure in accordance with Paragraph 2.1, “Supporting Devices”, and with National Electrical Code (NEC) requirements. Install hangers and supports to withstand forces for the UBC Seismic Zone indicated.

E. Install identification devices where required in accordance with the requirements of Section 16195, “Electrical Identification.” Engrave nameplates as indicated up to a maximum of three lines. Identification and name plates shall be in accordance with FAA C-1217f, paragraphs 4.16 and 4.16.1.

F. Wiring Methods.

1. General: All wiring shall consist of insulated copper conductors installed in metallic raceways, unless otherwise specified.
2. Conductor routing: Panel-boards, disconnect switches, etc., shall not be used as raceway for conductor routing other than conductors that originate or terminate in these enclosures. Isolated ground conductors will be allowed to traverse these enclosures.
3. Conductor separation: Power conductors shall be routed separately from all other conductor types. Route power conductors and other conductors in separate raceways in a metallic divider between the power conductors and the other conductors in the same raceway.

    a. Power cables of less than 600 volts may be installed in the same duct; however, 480/277V power cables shall be in separate raceways from 208/120V power cables.
    b. Power cables of less than 600 volts shall not be installed in the same duct with control, telephone, or signal type cables.

4. Neutral conductor: Shared/common neutrals shall not be permitted, i.e., each over current device shall have its own separate neutral conductor. Neutral conductor size shall not be less than the respective feeder or phase conductor sizes.
5. Ground conductor: Shared/common grounding conductors shall not be permitted, i.e., each over current device shall have its own separate ground conductor.

3.4 DEMOLITION

A. Where electrical work to remain is damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

B. Accessible Work Indicated to Be Demolished: Remove exposed electrical installation in its entirety.

C. Abandoned Work: Remove electrical conductors in their entirety. Cap and patch surface to match existing finish.

D. Removal: Remove demolished material from the Project site.

E. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

3.5 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for electrical installations. Perform cutting by skilled mechanics of the trades involved.

B. Repair disturbed surfaces to match adjacent undisturbed surfaces.

3.6 TOUCHUP PAINTING

A. Thoroughly clean damaged areas and provide primer, intermediate, and finish coats to suit the degree of damage at each location.

B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

3.7 FIELD TESTING

A. General: Perform the tests specified and other tests necessary to establish the adequacy, quality, safety, completed status, and suitable operation of each system. Repair or replace equipment that does not meet test requirements and retest. Tests shall be scheduled and approved in writing by COR at least 21 working days prior to conducting tests. Unless otherwise indicated, the contractor shall furnish all test instruments, materials and labor necessary to perform tests designated in Division 16 Sections. All tests shall be performed in the presence of the COR. All instruments shall have been calibrated within a period of two years preceding testing. Calibrations shall be traceable to applicable industry recognized standards.

B. An interim operating and performance test shall be performed for each major equipment item after installation is complete and before the item is placed in service. After mechanical systems have been completely installed and balanced, test each system for proper operation. Tests shall be conducted in the presence of the COR under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of the systems. Special tests on individual systems are specified under individual sections. Provide 21 days written notice to the COR for major tests. Contractor shall demonstrate, to the COR's satisfaction, proper operation of control devices by simulating actual operating conditions. Devices tested shall include, but not be limited to, flow and pressure controls, temperature controls, and system interlocks and alarms.

C. After final tests and adjustments have been completed, fully instruct the COR and other personnel as directed by the COR in details of operation and maintenance of electrical equipment, including control systems and fire alarm system as installed.

D. Motor Insulation Resistance Test: Motors shall be tested for ground or short circuits after installation, but before start up. Windings shall test free from short circuits and grounds. Minimum insulation resistance for motors, phase to phase and phase to ground shall not be less than 30 mega ohm measured with a 500 volt DC insulation resistance tester. Apply the test voltage for at least one minute after the reading has stabilized.

E. Load Balancing: After the Contractor Acceptance Inspection (CAI) of electrical systems, redistribute the loads where there is a greater than a twenty percent difference between readings in two or more phases, in accordance with Section 16470, “Panelboards.”

F. Complete the Electrical Test Report, Form 16050-1 included as Attachment No. 1. Provide the requested information for each panelboard and its power supply conductors. Perform insulation resistance tests in compliance with Section 16120, "Wire and Cables", on wires including the neutral before connection to source and to loads.

G. Complete the Motor Test Report, Form 16050-2 included as Attachment No. 2. Provide the requested information for each motor.

END OF SECTION 16050

ATTACHMENT NO. 1

Electrical Test Report

Project Name _____ Date _____ Sheet No. ___ of ___
Project No._____ Address_____

SERVICE TRANSFORMER SIZE			
NL SERVICE VOLTAGE			
FL SERVICE VOLTAGE			
PANEL OR SWBD SERVED FROM			
PANEL OR SWITCHBOARD			
LOCATION			
MANUFACTURER			
TYPE			
FEEDER O C PROTECTION			
FEEDER CONDUCTOR SIZE			
GROUND CONDUCTOR SIZE			

MEASURED CONDITIONS	PHASE			PHASE			PHASE		
	A	B	C	A	B	C	A	B	C
NO LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER CURRENT									
CONDUCTOR INSUL RESISTANCE0 AB									
CONDUCTOR INSUL RESISTANCE0 BC									
CONDUCTOR INSUL RESISTANCE0 CA									
CONDUCTOR INSUL RESISTANCE TO GROUND									
NEUTRAL INSUL RES TO GR W/GR CONN REMOVED									

ATTACHMENT NO. 2

Motor Test Report

Project Name _____ Date _____ Sheet No. ___ of ___
Project No._____ Address_____

DESTINATION		
LOCATION		
HORSEPOWER		
NEMA STARTER SIZE		
STARTER MFG. & CAT. NO.		
HEATER CAT. NO.		
MAXIMUM HEATER AMPS		
CONDUCTOR SIZE		
GROUND COND. SIZE		
SERVED FROM PNL OR MCC.		

MEASURED CONDITIONS	PHASE			PHASE		
	A	B	C	A	B	C
ACTUAL MOTOR CURRENT						
NAMEPLATE MOTOR CURRENT						
NO LOAD VOLTAGE						
FULL LOAD VOLTAGE						
CONDUCTOR INSUL. RESISTANCE Ø AB						
CONDUCTOR INSUL. RESISTANCE Ø BC						
CONDUCTOR INSUL. RESISTANCE Ø CA						
CONDUCTOR INSUL. RESISTANCE TO GR.						

SECTION 16100

RACEWAYS, BOXES, AND CABINETS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical and communication wiring.

B. Raceways include the following:

1. Rigid metal conduit (RMC).
2. Intermediate metal conduit (IMC).
3. Electrical metallic tubing (EMT).
4. Flexible metal conduit.
5. Liquid-tight flexible conduit.
6. Rigid nonmetallic conduit.

C. Boxes, enclosures, and cabinets include the following:

1. Device boxes.
2. Outlet boxes.
3. Pull and junction boxes.
4. Cable access box

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. American National Standards Institute (ANSI)

1. C80.1 Rigid Steel Conduit-Zinc Coated.
2. C80.3 Electrical Metallic Tubing-Zinc Coated.
3. C80.6 Intermediate Metal Conduit Zinc Coated.

B. Federal Aviation Administration (FAA)

1. STD 019e Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities.
2. C-1217f Electrical Work, Interior.

C. Federal Specifications (FS)

1. W-C-586 Conduit Outlet Boxes, Bodies, and Entrance Caps.

D. National Electrical Contractor's Association (NECA)

1. Standard of Installation.

E. National Electrical Manufacturers Association (NEMA)

1. 250 Enclosures for Electrical Equipment.
2. FB 1 Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies.
3. OS 1 Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

F. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

G. Occupational Safety and Health Administration (OSHA)

1. 1910.7 Nationally Recognized Testing Laboratories (NRTL)

H. Underwriters Laboratories (UL)

1. 1 Flexible metal conduit.
2. 6 Rigid Metal Conduit.
3. 50 Enclosures for Electrical Equipment.
4. 360 Liquid-tight Flexible Metal Conduit.
5. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
6. 514A Metallic Outlet Boxes.
7. 514B Fittings for Conduit and Outlet Boxes.
8. 797 Standard for Safety Electrical Metallic Tubing.
9. 870 Standard for Safety Wireways, Auxiliary Gutters and Associated Fittings.
10. 1242 Intermediate Metal Conduits.

I. Uniform Building Code (UBC)

1.3 SYSTEM DESCRIPTION

A. Conduit size is indicated on Drawings. Minimum size conduit shall be 3/4 inch diameter.

B. Each critical power circuit shall occupy one dedicated conduit or box, separated from other circuits.

1.4 SUBMITTALS

A. Shop drawings for nonstandard boxes, enclosures, and cabinets. Include layout drawings showing components, wiring, supports, and seismic bracing.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70 "National Electrical Code" for components and installation.

1. Boxes shall be sized in accordance with NEC Article 370.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in the "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

C. Comply with NECA "Standard of Installation."

D. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 GENERAL

A. Enclosures shall conform to NEMA standards.

B. All materials procured under this specification shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1 and UL 6.

B. Intermediate Metal Conduit: ANSI C80.6. Use for essential power systems where permitted by Code.

C. Electrical Metallic Tubing and Fittings: ANSI C80.3 and UL 797 with compression-type fittings. (Screw type fittings are not acceptable). Use for lighting, building power, fire alarm, environmental and communication circuits in concealed areas, such as: suspended ceilings, furred walls, raised floors, and where these circuits are not subject to physical damage.

D. Flexible Metal Conduit, Zinc Coated steel: UL 1 and FS WW-C-566

1. Liquid-tight Flexible Metal Conduit: Flexible metal conduit with PVC jacket: UL 360
2. Provide flexible metal conduit in minimum 24 inches or 10 diameter lengths for connection to motors and equipment subject to vibration and movement.
2. Conduit and fittings shall be type listed for grounding.

E. Fittings: NEMA FB 1 and UL 514B, compatible with conduit/tubing materials. Conduit expansion and deflection fittings shall be watertight. Fabricate from material compatible with conduit to be used. Expansion and deflection fittings shall be equipped with bonding jumper cable to provide electrical continuity. Lock-nut and bushings inside boxes or enclosures shall be grounding type.

2.3 OUTLET AND DEVICE BOXES

A. Sheet Metal Boxes: NEMA OS 1 and UL 514A.

B. Cast Metal Boxes: NEMA FB 1, type FD, cast ferroalloy box with threaded nubs, and with gasket cover.

C. Exposed Outlet Boxes: UL 514A steel, malleable iron or cast iron boxes with threaded conduit entry for surface mounting in areas having exposed conduit systems.

D. Flush Outlet Boxes: UL 514A hot-dip galvanized steel, square or rectangular, 2-1/8 inches deep by four inches square, with extension ring where necessary.

E. Boxes for lighting fixtures: Flush mounted or in concealed areas: octagonal, four inches by 2-1/8 inches deep, galvanized steel, with fixture stud supports and attachments to properly support ceiling and bracket type lighting fixtures. Surface mounted: malleable or cast iron boxes with threaded conduit hub.

F. Sheet Metal Boxes: UL 514B.

2.4 PULL AND JUNCTION BOXES

A. Small Sheet Metal Boxes: NEMA OS 1 and UL 514A.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of the raceway system. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine raceways prior to installation. No crushed or deformed raceway shall be installed.

3.2 WIRING METHODS

A. Indoors: Use the following wiring methods:

1. Connection to Vibrating Equipment (including transformers, hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Flexible metal conduit, except in wet or damp locations use liquid-tight flexible metal conduit.
2. Damp or Wet Locations: Rigid metal conduit.
3. Exposed: Rigid metal conduit.
4. Concealed: Electrical metallic tubing, intermediate metal conduit, rigid steel conduit (EMT shall only be used for lighting receptacles, communications, fire alarm, security, and environmental controls in concealed locations indoors).
5. Boxes and Enclosures: NEMA Type 1, except in damp or wet locations use NEMA Type 3.

B. Outdoors: Use the following wiring methods:

1. Exposed: Rigid or intermediate metal conduit.
2. Concealed: Rigid or intermediate metal conduit.
3. Underground, Single Run: PVC coated rigid galvanized steel conduit and fittings.
4. Underground, Grouped: PVC coated rigid galvanized steel conduit and fittings.
5. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Liquid-tight flexible metal conduit.
6. Boxes and Enclosures: NEMA Type 3R or Type 4.

C. Conduit Use:

1. Install rigid steel conduit (RMC) or intermediate metal conduit (IMC) for all distribution panel feeders, transformer feeders, motor control center feeders, and distribution switchboards.
2. Install electrical metallic tubing (EMT) for communication, lighting, and branch circuits.

3.3 INSTALLATION

A. Products shall be installed in accordance with FAA C-1217f and FAA STD-019e.

B. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions. Install to withstand forces for the UBC Seismic Zone indicated in Section 16050, ‘Basic Electrical Materials and Methods.”

C. Minimum size raceway shall be 3/4 inch, unless otherwise noted. Conduit for signal systems shall be as follows:

1. 1/2-inch conduit may be used for lengths not exceeding 50 feet. 3/4-inch conduit may be used for lengths not exceeding 100 feet.
2. 1-inch conduit shall be used for lengths exceeding 100 feet.
3. No run shall contain more than two (2) 90 degree bends, or the equivalent.
4. Provide pull and junction boxes required to meet the above criteria.

D. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors/raised floors.

1. Raceways shall not be attached to the ceiling suspension system.
2. Raceways shall not be attached to or supported by roof decks.
3. Do not anchor or strap raceways to wall furring channels or to other raceways.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.

F. Install raceways level and square and at proper elevations. Provide adequate headroom.

1. Install conduit to drain moisture to nearest outlet or pull box.

G. Complete raceway installation before starting conductor installation.

H. Support raceways and boxes as specified in Section 16050 "Basic Electrical Materials and Methods."

1. Boxes for fixtures on suspended ceilings shall be supported independently of the ceiling supports.
2. Boxes shall not be supported from sheet-metal roof decks.

I. Use temporary closures to prevent foreign matter from entering raceway.

1. Prevent the lodgment of plaster, dirt, or trash in raceways, boxes, fittings, and equipment during construction. Clogged raceways shall be entirely freed of obstructions or replaced. Clean each conduit run before pulling in conductors.

J. Make bends and offsets so the inside diameter is not reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and keep the straight legs of offsets parallel.

1. Prevent Bends in conduit that is 1 inch and larger shall have a minimum inside radii 12 times the nominal conduit diameter.
2. No run shall contain more than four (4) 90 degree bends, or the equivalent. Provide pull and junction boxes required to meet the bends criteria.

K. Use raceway fittings compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, except as otherwise indicated.

L. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions, except as otherwise indicated.

M. Floor and Wall Penetrations:

1. Penetrations through walls or floors shall be sealed to prevent moisture and rodent entry and to deter air transfer.
2. Seal penetrations of walls which separate individually temperature or humidity controlled areas, to prevent air circulation.

N. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.

1. Run parallel or banked raceways together, on common supports where practical.
2. Make bends in parallel or banked runs from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.

O. Join raceways with fittings designed and approved for the purpose and make joints tight.

1. Use bonding locknuts and bushings at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings for all conduits to protect conductors.
3. Provide expansion fittings for all raceways passing through the building expansion joints and conduit runs longer than 300 feet.

P. Where knockouts are used, provide double locknuts, one on each side with a grounding bushing or grounding locknut used on the inside.

Q. Raceway Supports: Comply with NFPA 70 and the following requirements:

1. Conform to manufacturer's recommendations for selecting and installing supports.
2. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
3. Support parallel runs of horizontal raceways together on trapeze-type or bracket-type hangers.
4. Spare Support Capacity: Size supports for multiple conduits so capacity can be increased by a 25 percent minimum in the future.
5. Support individual horizontal raceways with separate, malleable iron pipe hangers or clamps.
6. Hanger Rods: 1/4-inch diameter or larger threaded steel, except as otherwise indicated.
7. Spring Steel Fasteners: Specifically designed for supporting single conduits or tubing. Might be used malleable iron hangers for 1-1/2 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to channel and slotted angle supports.
8. In vertical runs, arrange support so that the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports, with no weight load on raceway terminals. Install supports simultaneously with raceway.
9. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs. safety allowance in the strength of each support.
10. Space supports for raceways in accordance with Table 1 of this section. Space supports for raceway types not covered by the above in accordance with the National Electrical Code (NEC).

11. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or thread less box connectors.

(Continued on next page)

TABLE 1: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1)	EMT (1)	RNC (1)
3/4	1 or 2	Flat ceiling or wall.	5	5	3
3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7	....
3/4	3 or more	Any location.	7	7	....
1	3 or more	Any location.			....
1 & larger	1 or 2	Flat ceiling or wall.	6	6	....
1 & larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10	....
1 & larger	3 or more	Any location.	10	10	....
3/4 and larger	....	Concealed.	10	10	....

VERTICAL RUNS

No. of Raceway Size (Inches)	RMC & Conductors in Run	Location	IMC (1,2)	EMT (1)	RNC (1)
3/4	....	Exposed.	7	7	....
1,1-1/4	....	Exposed.	8	8	....
1-1/2 and larger	....	Exposed.	10	10	....
Up to 2	....	Shaftway.	14	10	....
2-1/2	....	Shaftway.	16	10	....
3 & larger	....	Shaftway.	20	10	....
3/4 & larger	....	Concealed.	10	10	....

NOTES:
(1) Maximum spacing of supports (feet).
(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

ABBREVIATIONS:
EMT Electrical metallic tubing.
IMC Intermediate metal conduit.
RMC Rigid metal conduit.
RNC Rigid Non-metallic Conduit.

R. Miscellaneous Supports: Install metal channel racks for mounting cabinets, panel-boards, disconnects, control enclosures, pull boxes, junction boxes, and other devices except where components are mounted directly to structural features of adequate strength.

S. In open overhead spaces, cast boxes threaded to raceways need not be separately supported, except where used for fixture support; support sheet-metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.

T. Sleeves: Install for cable and raceway penetrations of concrete slabs and walls, except where core-drilled holes are used. Install for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

U. Firestopping: Apply to cable and raceway penetrations of fire-rated floor and wall assemblies. Perform firestopping as specified in Section 07270 "Fire-Stopping" to reestablish the original fire-resistance rating of the assembly at the penetration.

V. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cabinets, panelboards, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and by machine screws, welded threaded studs, or spring-tension clamps on steel.
2. Threaded studs driven by a powder charge shall not be used.
3. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or any other items.
4. In partitions of light steel construction use sheet-metal screws.
5. Drill holes in concrete beams so holes more than 1-1/2 inches deep do not cut main reinforcing bars.
6. Drill holes in concrete so holes more than 3/4 inch deep do not cut main reinforcing bars.
7. Fill and seal holes drilled in concrete and not used.
8. Select fasteners so the load applied to any fastener does not exceed 25 percent of the proof-test load. Use vibration and shock-resistant fasteners for attachments to concrete slabs.

W. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely, and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box. In addition a bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

X. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

Y. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight. Use insulating bushings to protect conductors.

Z. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb. tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

AA. Flexible Connections: Use maximum of 6 feet of flexible metallic conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid-tight flexible metallic conduit in wet or damp locations. Install separate ground conductor across flexible connections.

BB. Metal conduits shall be mechanically and electrically continuous between outlets, junctions and pull boxes, panels, cabinets and similar equipment.

CC. Conduits shall enter and be secured to enclosures so that each system is electrically continuous throughout.

DD. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

EE. Provide conduit support members required for proper and secure installation. Include stud supports, stems, mounting brackets, frames, and, if applicable, plaster rings.

1. Conduit supports shall employ materials which are suitable for the purpose. Cast metal parts other than malleable iron and cast-on rolled threads shall be designed to ensure structural adequacy.

FF. Field Cut Conduit: Where conduit has to be cut in the field, it shall be cut square using a hand or power hacksaw or approved pipe cutter using cutting knives. The cut ends of the field-cut conduit shall be reamed to remove burrs and sharp edges. Where threads have to be cut on conduit, the threads shall have the same effective length and shall have the same thread dimensions and taper as specified for factory-cut threads on conduit.

3.4 INSTALLATION - BOXES

A. Boxes: Shall be provided in the wiring or raceway system for pulling wires, making connections, and mounting devices or fixtures. Each box shall have the volume required by NFPA 70 for the number and size of conductors in the box.

1. Outlet boxes: Each outlet box shall have a machine screw which fits into a tapped hole in the box for the ground connection.
2. Mounting light fixtures: Boxes for mounting fixtures shall be not less than 4 inches square.
3. Concealed wiring: Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. The front edge of the box shall be flush or recessed not more than 1/4" from the finished wall surface (whether the finished surface is drywall, or drywall and a sound-absorbing material.
4. Boxes in masonry block or tile walls: Shall be square-cornered title-type, or standard boxes shall have square-cornered tile-type covers.
5. Wet locations: Cast metal boxes installed in wet locations and boxes installed flush with exterior surfaces shall have gasket.

B. Fixture boxes: Attach boxes to ceilings which are not suspended in at least two places. Distribute lighting fixture load over the ceiling boxes.

C. Mounting:

1. Install switch box on the strike side of the door at mounting height of 48 inches. Unless otherwise indicated, mounting height of receptacle boxes shall be 18 inches.
2. Height of a wall mounted outlet box is defined as the height from finished floor to horizontal center line of the cover plate.
3. Where outlets are indicated adjacent to each other, mount outlets in a symmetrical pattern with tops at the same elevation. Where outlets are indicated adjacent, but with different mounting heights, line up outlets on a vertical line.
4. Verify the final location of each outlet before installation. Remove and relocate outlet boxes placed in an unacceptable position.
5. At fire rated partitions, offset boxes to prevent back-to-back installation.

D. Box openings: Provide only the openings necessary to accommodate the conduits at the individual location. When this is not practical, plug unused openings.

E. Junction, transition and pull boxes:

1. Install junction, transition and pull boxes so that covers are readily accessible. Boxes in concealed areas of ceiling or wall shall be accessible through removable panels.
2. Locate pull boxes to permit easy pulling of wire or cables.
3. Securely attach boxes to structural and framing members using compatible fasteners of adequate size.
4. Bolt wall mounted boxes to steel profiles fastened to the wall.

F. Grounding: Provide each box with a green machine screw. Screw into tapped hole in the box for ground wire or lug connection.

3.5 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by the manufacturer.

B. Cap stubbed up raceways, including raceways in cabinets, immediately upon installation. The use of paper or rag wads is not acceptable.

C. Galvanic corrosion protection: Avoid dissimilar metals in contact anywhere in conduit runs. Where contact cannot be avoided at conduit terminations, treat the connection with joint compound that eliminates galvanic corrosion. Where dissimilar metals are in contact: such as at aluminum cable tray or enclosures and steel supports, separate contact surfaces by using gaskets, non-absorptive tape, or coating to prevent galvanic corrosion.

3.6 CLEANING

A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 16100

SECTION 16120

WIRES AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. American Society for Testing and Materials (ASTM)

1. B3 Standard Specification for Soft or Annealed Copper Wire.
2. B8 Standard Specification for concentric-lay-stranded copper conductors; hard, medium hard, or soft.
3. D1000 Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes used for electrical and electronic applications.

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior.
2. STD-019e Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities.

C. Federal Specification (FS)

1. W-S-610 Splice Connectors.
2. QQ-W-343 Wire, Electrical, Copper, Uninsulated.

D. National Electrical Contractors Association (NECA)

1. Standard of Installation.

E. National Electrical Manufacturers Association (NEMA)

1. WC3 Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
2. WC5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
3. WC8 Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
4. WC26 Wire and Cable Packaging.

F. International Electrical Testing Association (IETA)

1. ATS Acceptance Testing Specification for Electric Power Distribution Equipment and Systems

D. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

G. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Requirements for Nationally Recognized Testing Laboratories (NRTL)

H. Underwriters Laboratories (UL)

1. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.

1.3 SUBMITTALS

A. Field test reports indicating and interpreting test results relative to compliance with performance requirements of testing standard.

1.4 QUALITY ASSURANCE

A. Testing Firm Qualifications: An independent testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1910.7, or shall be a full member company of the International Electrical Testing Association (NETA).

1. Testing Firm's Field Supervisor Qualifications: A person currently certified by the NETA National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Comply with NFPA 70, NEC, for components and installation.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in the NEC, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

D. Installer Qualifications: Cable splices shall be performed by experienced and qualified cable splicer. The workmen shall be licensed if required by the authority having jurisdiction.

1.5 SEQUENCING AND SCHEDULING

A. Coordination: Coordinate layout and installation of cable with other installations.

1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the COR.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver wire and cable according to NEMA WC-26.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA-C-1217f and FAA STD-019e.

2.2 BUILDING WIRES AND CABLES

A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Applications" Article.

B. Rubber Insulation: Conform to NEMA WC 3.

C. Thermoplastic Insulation: Conform to NEMA WC 5.

D. Solid conductor for 10 AWG and smaller; stranded conductor for larger than 10 AWG. Stranded conductors shall be tin coated, ASTM B8, Class B.

E. All wire and conduit sizes are based on copper conductors with 75 degrees C insulation.

F. Size: Minimum 12 AWG. Minimum 10 AWG for 120 volt circuits where circuit length (one way) exceeds 75 feet from source, and 10 AWG for 277 volt circuits where circuit length (one way) exceeds 150 feet from source. Communication and control systems wiring size shall be in accordance with Manufacturer's requirements or as specified elsewhere in the specifications.

1. Stranded conductors may be used with wire compression connectors or a pressure washer type lug.
2. Stranded conductors smaller than 10 AWG are allowed in applications where vibration and flexing may be encountered.

G. Conductor type: Soft drawn, annealed copper (aluminum conductors are not acceptable).

1. Power conductors shall be single conductor type.
2. Control interconnection between equipment shall be jacketed type multi-conductor.
3. Instrumentation conductor shall be twisted pair, shielded, jacketed type.
4. Conductors used for lighting and receptacle branch circuits shall be single conductor type.

H. Conductor Color Codes: Refer to Section 16195, "Electrical Identification," for conductors No. 4 AWG and larger, where factory color coding is not available.

1. Feeder conductors to panels and three phase circuits shall be factory color coded as follows:

   a. 208/120 (240) Volt System

      1) Phase A: Black
      2) Phase B: Red
      3) Phase c: Blue
      4) Neutral: White
      5) Ground: Green

   b. 480/277 Volt System

      1) Phase A: Yellow
      2) Phase B: Brown
      3) Phase C: Orange
      4) Neutral: Grey
      5) Ground: Green

2. Single-phase branch circuits shall be factory color coded as stated above, or identified in accordance with Section 16195, “Electrical Identification.”
3. Switch leg conductors shall be violet insulated.
4. Control Cables shall be IAW NEMA WC5.

I. Un-insulated conductors shall be copper and comply with F.S. QQW-343.

J. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Applications" Article.

2.3 CONNECTORS AND SPLICES

A. UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated. Select to comply with Project's installation requirements and as specified in Part 3 "Applications" Article.

B. Connectors, Splice Sleeves and Terminal Lugs: Wire and cable connectors, lugs, and sleeves shall be in compliance with UL 486A, and the following:

   1. For splices of 10 AWG and smaller building wires in lighting circuits, use tin plated copper compression type connector caps with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation; and
   2. Use ring tongue compression type terminators with insulated barrel on all stranded conductors used in control wiring.
   3. Crimp type connectors not permitted on solid conductors.

C. Insulating Tape: ASTM D1000. As a minimum, rate equal to conductor insulation. Rubber tape shall be silicon rubber with silicon pressure sensitive adhesive.

D. Bundling Straps: Nylon straps with a locking hub or head on one end and a taper on the other.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Feeders: Type THHN/THWN, copper conductor, in raceway.

B. Indoor Branch Circuits: Type THHN/THWN, copper conductor, 90 degree C insulation in raceway. To use in dry locations only application for lighting and receptacle circuits.

C. Exterior Branch Circuits: Type THWN, copper conductor, 75 degree C insulation, in raceway.

D. Fire Alarm Power Circuits: Type THHN/THWN, copper conductor, in raceway.

E. Communication System wiring (to include telephone cable, fire alarm cable, intercommunication wiring and public address/music system) shall be as specified under applicable sections and specific requirements of the NEC. Use copper wire or fiber optics cable only. Aluminum wire is not permitted.

3.3 INSTALLATION

A. Materials procured and installed in this Section shall be in accordance with FAA-C-1217f and FAA STD-019e.

B. Install wires and cables as indicated, according to manufacturer's written instructions and the NECA "Standard of Installation."

C. Remove existing wire from raceway before pulling in new wire and cable.
D. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.

1. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
3. Bend to radii not less than the minimum bending recommended by manufacturer or 12 times the outer diameter of cable. Do not exceed the pulling tension recommended by manufacturer.

E. Cable shall be installed in a manner to prevent harmful stretching of the conductor, injury to the insulation or damage to the outer protective covering.

F. Install exposed cable, parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.

G. Conductor Splices: Keep to minimum.

1. Splices shall be made only at outlets, junction boxes, or accessible raceways.
2. Wire nuts may only be used to splice conductors sized No. 10 AWG and smaller.
3. Compression connectors shall be used to splice conductors No. 8 and larger.
4. All splices, including those made with insulated wire nuts shall be insulated with electrical tape or heat-shrink tubing to a level equal to that of the factory insulated conductors.
5. Splicing of ungrounded conductors in panelboards is not permitted.
6. Splices shall be made with solder-less connectors conforming to UL 486A, UL 486C, UL 486E and FS W-S-610.
7. No splices shall be allowed on critical feeders.
8. Install splices and insulating tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
9. Use splice and tap connectors that are compatible with conductor material.
10. Splicing methods and material shall be of a type recommended by the manufacturer of the splicing material for the particular type of cable being spliced and shall be approved by the COR prior to installation

H. Conductors for emergency lighting and fire alarm systems shall be kept completely independent from any other system as well as each other.

I. Grounding: Materials and equipment installed at this facility shall be grounded in accordance with FAA-C-1217f.

J. Separate neutral and ground wires shall be provided for each over current protection device. Each branch circuit shall have its own neutral and ground conductor. Common neutral or ground is not acceptable.

K. Neutral conductors shall extend from the neutral bus where the phase conductors originate.

L. Install electrical identification devices specified in Section 16195 “Electrical Identification”, at terminations, immediately after installing wires and cables.

3.4 FIELD QUALITY CONTROL

A. Testing, General: Cables shall be tested prior to installation and again upon completion of the installation. Testing shall be accomplished before connection is made. Tests shall be performed in the presence of the COR.

1. Upon installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

   a. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA Standard ATS, Section 7.3.1. Certify compliance with test parameters.
   b. Test wire and cable for continuity or circuitry, and also for short circuits.

B. Insulation Resistance Tests: Feeder and Branch Circuit insulation tests shall be performed after installation, but before connection to equipment.

1. Conductors shall test free from short circuits and grounds, and have a minimum phase-to-phase and phase-to-ground insulation resistance of 30 mega ohms when measured with a 500-volt DC insulation resistance tester. The contractor shall submit a letter type test report to the COR prior to final inspection of the Work. The report shall list the tests performed and results obtained.

   a. Apply the test voltage for at least one minute after motor reading has stabilized.

2. Where new and existing cables are to be spliced, both cables shall be tested. The resistance values for new cable shall not be less than those recommended by the cable manufacturer. Resistance values for existing cable insulations shall not be less than 80 percent of the value for a comparable new cable. Report to COR, location of existing cable installation with less than 80 percent insulation value of new cable to be spliced.

C. Correct malfunctioning products at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

END OF SECTION 16120

SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes various types of receptacles, connectors, switches, and finish plates.

1.2 REFERENCE STANDARDS

A. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior
2. STD-019e Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities

B. Federal Specifications (FS)

1. W-C-596 General and Associated Detailed Specifications: Connector, Plug Receptacle, and Cable Outlet, Electrical Power
2. W-S-896E Switch, Toggle, Flush Mounted

C. National Electrical Manufacturers Association (NEMA)

1. WD1 General Requirements for Wiring Devices

D. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

E. Underwriters Laboratories (UL)

1. 20 Standard for Safety General Use Snap Switches.
2. 498 Standard for Safety Attachment Plugs and Receptacles.
3. 943 Ground Fault Circuit Interrupters .

F. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Requirements for Nationally Recognized Testing Laboratories.

1.3 SUBMITTALS

A. Product data for each product specified.

B. Operation and maintenance data for materials and products specified in this Section to include in the Operating and Maintenance Manual.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70, NEC, for devices and installation.

B. Listing and Labeling: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: An “NRTL” as defined in OSHA Regulation 1910.7.

1.5 COORDINATION

A. Device plates shall be white finish. Convenience receptacles shall be white; and computer receptacles shall be blue..

B. Cord and Plug Sets: Match cord and plug sets to equipment requirements.

1.6 LIMITED WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 WIRING DEVICES

A. Comply with NEMA Standard WD 1, "General Purpose Wiring Devices."

B. Enclosures: NEMA 1 equivalent, except as otherwise indicated.

C. Color: White or Ivory, except as otherwise indicated or required by Code.

D. Receptacles, General: All receptacles shall be specification grade in accordance with NEMA WD 1. Wiring terminals shall be of the screw-type. Receptacles with push-in connections or a combination of screw-type and push-in connectors are not acceptable.

1. Straight-Blade: Except as otherwise indicated, comply with Federal Specification W-C-596 and heavy-duty grade of UL Standard 498. Provide NRTL labeling of devices to verify these compliances.

    a. Rated 20 amperes at 125 and 250 volts AC. 125 volt AC receptacles shall have NEMA WD1 type 5-20R configuration.
    b. Heavy duty, general use of fire resistant non-absorptive thermoplastic material.
    c. Two-pole, three wire grounding type with polarized parallel slots.
    d. Side wired with two screws for each terminal and one screw for grounding.
    e. Grounding pole connected to mounting yoke.

2. Ground-Fault Circuit Interrupter Receptacles: UL Standard 943, "Ground Fault Circuit Interrupters," feed-through type, with integral NEMA 5-20R (UL Group I, Class A), duplex receptacle arranged to protect connected downstream receptacles on the same circuit.

E. Wall Switches: NRTL listed and labeled as complying with UL Standard and with Federal Specification W-S-896.

1. Rated 20 amperes at 120 and 277 volts AC, as indicated.
2. Heavy-duty, general use, toggle type, quiet operation, with brown handle and body of fire resistant, non-absorptive, thermoplastic material.
3. Single pole, double pole, three or four way, as indicated.
4. Silver alloy contacts.
5. Screw-type wiring and grounding terminals. Push-in is not acceptable. Connect grounding screw to the mounting yoke.
6. Mounting yoke of corrosion resistant material with plaster type ears.

F. Dimmer Switches: Modular full-wave solid-state units with integral, quiet on-off switches, and audible and electromagnetic noise filters. Color: Ivory.

1. Control: Continuously adjustable linear slide type. Single-pole or 3-way switch to suit connections.
2. Incandescent Lamp Dimmers: not used.
3. Fluorescent Lamp Dimmers: Modular dimmer switches compatible with dimmer ballast's. Trim potentiometer adjusts low-end dimming. Dimmer-ballast combination is capable of consistent dimming to one foot candle brightness.
4. Modular full-wave solid-state units with integral, quiet on-off switches, and audible and electromagnetic noise filters.

G. Device Plates: Single and combination types that mate and match with corresponding wiring devices. Features include the following:

1. Color: Matches wiring device except as otherwise indicated.
2. Plate-Securing Screws: Metal with heads colored to match plate finish.
3. Material for Finished Spaces: Thermoplastic material.
4. Material for Unfinished Spaces: Raised type galvanized steel.

5. Telephone and communication outlets shall be provided with a blank cover plate unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies plumb and secure, with alignment tolerance of 1/16 inch.

B. Install wall plates when painting is complete.

C. Arrangement of Devices: Except as otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles at bottom. Group adjacent switches under single, multi-gang wall plates.

1. Install switches up or to left for ON position.
2. Mount receptacles in uniform position and same polarity.

D. Protect devices and assemblies during painting.

E. Use green pigtail to connect the receptacle ground terminal to the box terminal.

3.2 IDENTIFICATION

A. Comply with Section 16195 "Electrical Identification."

1. Switches: Where 3 or more switches are ganged, and elsewhere where indicated, identify each switch with approved legend engraved on wall plate.
2. Receptacles: Identify the panelboard and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on both faces of plate and durable wire markers or tags within outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Testing: Test wiring devices for proper polarity and ground continuity. Operate each operable device at least 6 times.

B. Replace damaged or defective components.

C. Check tightness of connections to switches and receptacles.

3.4 CLEANING

A. General: Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 16140

SECTION 16190

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

B. Devices must be installed per requirements for Seismic Zone 4.

1.2 REFERENCE STANDARDS

A. Reference standards noted are applicable only to the extent specified.

B. National Fire Protection Association (NFPA)

1. 70: National Electrical Code (NEC).

C. Underwriters Laboratories (UL)

1.3 SUBMITTALS

A. Product data for each type of product specified.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation must comply with NFPA 70.

B. Electrical components must be listed and labeled by UL or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 - PRODUCTS

2.1 COATINGS

A. Coating: Supports, support hardware, and fasteners must be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors must be hot-dip galvanized.

2.2 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type.
2. Toggle Bolts: All steel springhead type.
3. Powder Actuated fasteners: Not Allowed.

C. U-Channel Systems: 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

D. Fasteners for plastic-laminated and metal signs: Self-tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat end lock washers.

E. Provide steel channel supports with 9/16-inch diameter holes at a maximum of 8 inches on center, in at least 1 surface.

1. Fittings and accessories to mate and match with channels and to be from same manufacturer.

2.3 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: ASTM A53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with welded spiral seams or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:

a. 3-inch and smaller: 20-gage.
b. 4-inch to 6-inch: 16-gage.
c. over 6-inch: 14-gage.

2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

D. Supplementary Structural Supports: ASTM A36 steel shapes

1. Supports and supporting devices must be designed and installed to withstand the local code equivalent of a minimum UBC Seismic Zone 4 force.

2. Provide the installation of supplementary structural supports required for attachment of hangers and other devices supporting electrical equipment and conduits.

3. Members welded to main structural members must be equal to the specification for the main structural member.

4. Size support members for their actual loads and safety factors without excessive deflection and with consideration for rigidity under vibration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.

2. Strength of each support must be adequate to carry design load plus 25 percent for future use, multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lb., provide additional strength until there is a minimum of 200 lb. safety allowance in the strength of each support.

3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

4. Support parallel runs of horizontal raceways together on trapeze-type hangers.

5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. Space supports for raceways in accordance with Table I of section 16100. Space supports for raceway types not covered by the above in accordance with NEC.

7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.

8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

9. Neither raceways nor boxes must be fastened to suspended ceiling supports.

D. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

E. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, support the bar hanger from the building structure, not on the ceiling cross members.

1. Cast metal boxes having threadless connectors and sheet-metal boxes must be supported directly from the building structure or by bar hangers.

F. Sleeves: Install in concrete slabs and walls and all other fire- rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL- listed fire stopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with requirement of Section 07840 "Through-Penetration Fire stopping Systems."

G. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, lighting fixtures, and control components in accordance with the following:

1. Fasten by means of wood screws, carriage bolts, or lag screws of equal holding strength on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and machine screws, or spring-tension clamps on steel. Do not weld conduit, pipe straps, to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete must not cut the main reinforcing bars. Patch holes that are not used with like and kind materials.

3. Coordinate any cutting or boring of structural beams with Structural Engineer prior to any work being done.

4. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

5. Coordinate with structural engineer on expansion joints used to support raceways.

H. Tests: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:

1. Expansion anchors.
2. Toggle bolts.

I. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

END OF SECTION 16190

SECTION 16195

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes identification of electrical materials, equipment, and installations.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. American National Standards Institute (ANSI)

1. A 13.1 Scheme for the Identification of Piping Systems
2. C2 National Electrical Safety Code

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, interior

C. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

1.3 SUBMITTALS

A. Components and installation shall comply with NFPA 70.

B. Comply with requirements of ANSI standard A13.1, with regard to type and size of lettering for raceway and cable labels.

C. Samples for each color, lettering style, and other graphic representation required for tubing, tags, labels, markers, and other identification materials; samples of labels and signs.

D. Shop drawings showing installation method for each type of identification device.

1.4 QUALITY ASSURANCE

A. Components and installation shall comply with NFPA 70.

B. Comply with the requirements of ANSI A13.1 with regard to type and size of lettering for raceway and cable labels.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.

B. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f. Identification and nameplates shall be in accordance with FAA C-1217f, paragraphs 4.16 and 4.16.1.

B. Manufacturer's Standard Products: Where more than one type is listed for a specified application. Selection is Installer's option. Provide single type is for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.

C. Conform to ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size.

1. Color: Black legend on orange field.
2. Legend: Indicates voltage and service.

D. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl. Legend over-laminated with clear, weather- and chemical-resistant coating.

E. Heat Shrink Tubing: Preprinted, embossed, permatized, 20 year life. Size to suit conductors; lettering shall be legible after heat shrinking.

F. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic bands sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

G. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch wide.

H. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with pre-printed numbers and letters.

I. Plasticized Card-stock Tags: Vinyl cloth with pre-printed legends. Orange background, except as otherwise indicated, with eyelet for fasteners.

J. Brass Tags: Metal tags with stamped legend, punched for fasteners. Dimensions: 2 inches by 2 inches by 0.05 inch.

2.2 ENGRAVED NAMEPLATES AND SIGNS

A. Manufacturer's Standard Products: Where more than one type is listed for a specified application. Selection is Installer's option. Provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.

B. Engraving Stock: Melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 sq. in., 1/8 inch thick for larger sizes.

1. Engraved Legend: White letters on black field.
2. Punched for mechanical fasteners.

C. Interior Warning and Caution Signs: Pre-printed aluminum, baked enamel finish with 1/4 inch grommets in corners for mounting.

1. Color, size and legend: appropriate to the application.
2. Punched for fasteners.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, non-fading, preprinted, cellulose acetate butyrate signs with 0.0396-inch, galvanized steel backing, with colors, legend, and size appropriate to the application. 1/4-inch grommets are in corners for mounting.

E. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties with the following features:

1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 lb. minimum.
3. Temperature Range: Minus 40 to 185 deg F.
4. Color: As indicated where used for color coding.

B. Paint: lkyd-urethane enamel over primer as recommended by enamel manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install identification devices according to manufacturer's written instructions.

B. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

C. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations used in the Contract Documents or required by codes and standards. Use consistent designations throughout the Project.

D. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

E. Self-Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.

F. Install painted identification as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime Surfaces: For galvanized metal, use single-component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty, acrylic-resin block filler. For concrete surfaces, use clear, alkali-resistant, alkyd binder-type sealer.
3. Apply one intermediate and one finish coat of silicone alkyd enamel.
4. Apply primer and finish materials according to manufacturer's instructions.

G. Identify Raceways with Color Banding: Band exposed and accessible raceways of the systems listed below for identification.

1. Bands: Pretensioned, snap-around, colored plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of 2-color markings in contact, side by side.
2. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25 feet in congested areas.
3. Colors: As follows:

    a) Fire-Alarm System: Red.
    b) Fire-Suppression Supervisory and Control System: Red and yellow.
    c) Security System: Blue and yellow.
    d) Mechanical and Electrical Supervisory System: Green and blue.
    e) Telecommunications System: Purple and White.

H. Install Circuit Identification Labels on Boxes: Label externally as follows:

1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
2. Concealed Boxes: Plasticized card-stock tags.
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

I. Color-Code Conductors: The following field-applied color-coding methods may be used in lieu of factory-coded wire listed in Section 16120 "Wires and Cables" for sizes larger than No. 4 AWG. Contractor shall demonstrate non-availability of factory colored wire before using this application

1. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last 2 turns of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.

   a. Where conductors are color coded by this method, they shall be color coded in accessible raceways, panelboards, outlets, and switches, as well as at all terminations. Conductors in accessible raceways shall be color coded so that by removing or opening any cover, the coding will be visible.
   b. Phase, ground, and neutral conductors shall be color coded in accordance with Section 16120, "Wires and Cables."

2. Green insulated conductors shall not be re-identified for purposes other than grounding.

3. White or neutral grey conductors shall not be re-identified for purposes other than grounded neutrals.

J. Apply identification to conductors as follows:

1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.

2. Power and Lighting Circuits at Enclosure and at terminations: Identify each conductor with panel designation, circuit number, voltage, and phase.

3. Control and Communications Circuits at Enclosure and at terminations: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color coding, or cable marking tape.

K. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation.

2. Emergency-Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch-high lettering for emergency instructions on power transfer, and other emergency operations.

L. Install identification as follows:

1. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication,

signal, and alarm systems, unless units are specified with their own self-explanatory identification. Provide equipment, required under Division 16, as follows: with nameplate indicating equipment name, system voltage(s) and phase. Except as otherwise indicated, provide a single line of text with 1/2-inch-high lettering on 1-1/2-inch-high label; where 2 lines of text are required, use 2-inch-high label. Apply labels for each unit of the following categories of equipment:

a) Panelboards, electrical cabinets, and enclosures.
b) Access doors and panels for concealed electrical items.
c) Motor starters.
d) Control devices.

2. Label conduit at each end and at pull boxes with characters a minimum 1/4 inch high.

3. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

END OF SECTION 16195

SECTION 16452

GROUNDING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. American Society for Testing and Materials (ASTM)

1. B3 Soft or Annealed Copper Wire
2. B8 Concentric-Lay-Stranded Copper Conductors; Hard, Medium Hard, or Soft
3. B33 Tinned Soft or Annealed Copper Wire for Electrical Purposes.
4. E699 Standard Criteria for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating Building Components in accordance with Test Methods promulgated.

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior
2. STD-019e Lightning Protection, Grounding, Bonding and shielding Requirements for Facilities.
3. Order 6950.19A Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation.

C. National Fire Protection Association (NFPA)

1. 70 National electrical Code (NEC)
2. 780 Lightning Protection Code

D. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 National Recognized Testing Laboratories (NRTL)

E. Underwriters Laboratories (UL)

1. 46 7 Grounding and Bonding Equipment
2. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.

1.3 SUBMITTALS

A. Product data for connectors and connection materials, and grounding fittings.

B. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

C. Field tests and observation reports certified by the testing organization and indicating and interpreting the test reports for compliance with performance requirements.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7, or a full member company of NETA.

1. Testing Agency Field Supervision: Use persons currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Comply with FAA specification C-1217f, FAA-STD-019e, and FAA Order No. 6950.19A.

C. Comply with NFPA 70, National Electrical Code.

D. Comply with UL 467.

E. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 GROUNDING AND BONDING PRODUCTS

A. Products: Of types indicated and of sizes and ratings to comply with NEC, FAA specification C-1217f, FAA-STD-019e, and FAA Order No. 6950.19A. Where types, sizes, ratings, and quantities indicated are in excess of requirements above, the more stringent requirements and the greater size, rating, and quantity indications govern.

2.3 WIRE AND CABLE GROUNDING CONDUCTORS

A. Comply with Section 16120 "Wires and Cables." Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.

1. Material: Copper. Use only copper wire for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone and similar materials.
2. Size: Minimum allowable size shall not be less than #12 AWG, in addition to compliance with NEC.

B. Equipment Grounding Conductors: Insulated with green color insulation.

C. Grounding-Electrode Conductors: Stranded cable.

D. Bare Copper Conductors: Conform to the following:

1. Solid Conductors: ASTM B3.
2. Assembly of Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.

2.4 MISCELLANEOUS CONDUCTORS

A. Braided Bonding Jumpers: Where electrical continuity across the shock mounts is necessary, bonding jumpers shall be installed across each shock mount. Jumpers of this application should have a maximum thickness of 0.025 inch, so that the damping efficiency of the mount is not impaired. In severe shock and vibration environments, solid straps may be corrugated, or flexible wire braid may be used. Braids are to be terminated with copper ferrules.

B. Raceway Bonding Jumpers: Copper, minimum size #6 AWG unless otherwise noted.

2.5 CONNECTOR PRODUCTS

A. General: Listed and labeled as grounding connectors for the materials used.

B. Pressure Connectors: High-conductivity-plated units.

C. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

PART 3 - EXECUTION

3.1 APPLICATION

A. Grounding:

1. General: FAA grounding requirements often exceed those of NEC; therefore, grounding system shall be as indicated in Contract Drawings, and as specified herein.
2. Materials procured and installed in this Section shall be in accordance with FAA C-1217f, FAA STD-019e and FAA Order 6950.19a.

B. Equipment Grounding Conductors: All metallic non-current carrying parts of electrical equipment shall be grounded with equipment grounding conductors whether or not shown on the drawings. Equipment grounding conductors shall be green insulated copper conductors unless otherwise indicated. When these conductors are not sized nor shown on the Contract Drawings, size them in accordance with Table 250-95 of the NEC, "Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment. In no case, however, shall these conductors be smaller than No. 12 AWG.

1. Install separate green, equipment grounding conductor for each over current device, and with all feeder and branch circuit conductors.
2. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and above, including air cleaners and heaters. Conductor to each unit device and to air duct shall be bonded.

3.2 INSTALLATION

A. Materials procured and installed in the Section shall be in accordance with FAA C-1217f, FAA STD-019e and FAA Order 6950.19a.

B. General: The grounding requirements exceed those of the NEC. Grounding system shall be as indicated on the contract drawings and as specified herein.

C. Grounding Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Equipment Enclosure Grounding: Bare wire, wrapped around connecting screws or mounting bolts and screws is not acceptable as a grounding connection. All ground lugs shall be of a non-corrosive material suitable for use as a grounding connection, and must be compatible with the type of metal being grounded. Ground lugs shall be mounted on clean, bare metal surfaces that are free of paint, rust, etc.

E. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

3.3 CONNECTIONS

A. Materials procured and installed in the Section shall be in accordance with FAA C-1217f, FAA STD-019e and FAA Order 6950.19a.

B. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
2. Make connections with clean bare metal at points of contact.
3. Coat and seal connections involving dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
4. Indoor exothermic welds shall be smokeless type.

C. Exothermic Welded Connections: Use for connections to structural steel. Comply with manufacturer's written recommendations. Welds are puffed up or shown convex surfaces indicating improper cleaning are not acceptable.

D. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs.

E. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, or at non-metallic or non-conductive housings, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors shall be bonded.

F. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torque requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A.

G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Mechanical connections using a Burndy “Hyground Connector” or equipment when operated at a force of 24,000 pounds are acceptable as FAA approved pressure connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on ground conductor. Hydraulically crimped connectors are not acceptable in a lightning protection system.

3.4 SYSTEM AND EQUIPMENT GROUNDING

A. Install grounding conductor(s) in each conduit carrying branch or feeder conductors and in conduit for control wiring. Each over current device shall have its own individual grounding conductor. Grounding conductor shall have insulation rating equivalent to phase conductor insulation. Insulated grounding conductors shall be connected to the ground terminal at both ends and to junction, transition, pull and fixtures boxes along the route. Under no circumstances shall this conductor be omitted from the electrical system, nor shall a separate grounding system, such as the equipment grounding or signal grounding, be used as a substitute.

B. Metallic raceway housing the equipment grounding conductor shall be electrically continuous.

C. Where there are parallel conductors of a feeder installed in more than one raceway, install an equipment grounding conductor in each raceway.

D. Ground the ends of all conduit runs using grounding bushings, except for receptacle and lighting branch circuits.

E. Splices of grounding conductors inside conduits are not acceptable.

3.5 FIELD QUALITY CONTROL

A. Independent Testing Organization: Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.

B. Tests:

1. Subject the completed grounding system to a megger test at each location where a maximum ground resistance level is specified.

C. Bolting Resistance: Spot test to verify that ground cable bolted connections have a DC resistance of maximum one milliohm, when measured with a bridge type milliohmeter or similar instrument.

D. Continuity: Test grounding conductors, sheet metal, metallic conduits, equipment enclosure, metallic enclosures, and lighting fixtures for continuity to grounding system.

E. Deficiencies: Where ground resistances exceed specified values, modify the grounding system to reduce resistance values. Where measures are directed that exceed those indicated the provisions of the Contract, covering changes will apply.

F. Report: Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

END OF SECTION 16452

SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V or less.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. American Society for Testing and Materials (ASTM)

1. B187 Standard Specification for Copper Bar, Bus Bar, Rod and Shapes.
2. E 699 Standard Criteria for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating Building Components in Accordance with Test Methods Promulgated by ASTM Committee.

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior.
2. STD-019e Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities.

C. Federal Specification (FS)

1. W-P-115 Panel, Power Distribution.

D. Institute for Electrical and Electronics Engineers (IEEE)

1. C62.1 Standard for Gapped Silicon-Carbide Surge Arrestors for AC Power Circuits.
2. C62.11 Standard for Metal-Oxide Surge Arrestors for Alternating Current Power Circuits.
3. C62.41 Recommended Practice on Surge voltage in Low-Voltage AC Power Circuits.

E. International Electrical Testing Association (NETA)

1. ATS Acceptance Testing Specification for Electric Power Distribution Equipment and Systems.

F. National Electrical Manufacturers Association (NEMA)

1. AB1 Molded Case Circuit Breakers and Molded Case Switches.
2. PB1 Panelboards.
3. PB 1.1 General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.
4. 250 Enclosures for Electrical Equipment (1000 Volts or Less)

G. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC).

H. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Requirements for A National Recognized Testing Laboratories (NRTL).

I. Underwriters Laboratories (UL)

1. 50 Enclosures for Electrical Equipment.
2. 67 Panelboards.
3. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
4. 489 Molded-Case Circuit Breakers and Circuit Breaker Enclosures.
5. 870 Wireways, Auxiliary Gutters and Associated Fittings

1.3 DEFINITIONS

A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.4 SUBMITTALS

A. Product data for each type panelboard, accessory item, and component specified.

B. Shop drawings from manufacturers of panelboards including dimensioned plans, sections, elevations, supports, and seismic bracing. Show tabulations of installed devices, major features, and voltage rating. Include the following:

1. Enclosure type with details for types other than NEMA Type 1.
2. Bus configuration and current ratings.
3. Short-circuit current rating of panelboard.
4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
5. Characteristic time current curves of every type of circuit breaker.
6. Surge Protective Devices for feeder and branch panels.

C. Wiring diagrams detailing schematic diagram including control wiring, and differentiating between manufacturer-installed and field-installed wiring.

D. Qualification data for field-testing organization certificates, signed by the Contractor, certifying that the organization complies with the requirements specified in Quality Assurance below.

E. Report of field tests and observations certified by the testing organization.

F. Panel schedules for installation in panelboards. Submit final versions after load balancing.

G. Maintenance data for panelboard components, for inclusion in Operating and Maintenance Manual instructions specified in Section 16050 “Basic Electrical Materials and Methods.” Include instructions for testing circuit breakers.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1910.7, or shall be a full member company of NRTL.

1. Testing Agency’s Field Supervision: Person currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this section.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

C. Field-Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

D. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

E. NEMA Standard: Comply with NEMA PB1.

F. UL Standards: Comply with UL 50.

G. Overcurrent Protective Devises (OCPD): Provide circuit breakers in accordance with NEMA AB1 and UL 489.

1.6 EXTRA MATERIALS

A. Keys: Furnish two spares of each type for panelboard cabinet locks.

B. Touch-up Paint for panelboards: One half-pint container.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 PANELBOARD FABRICATION

A. Panelboards shall be circuit breaker equipped, dead-front type, and shall conform to Federal Specification W-P-115, Type I, Class 1.

B. Enclosures: UL 50, galvanized steel, flush- or surface-mounted cabinets. Panelboards shall be listed and labeled by Underwriters Laboratories, Inc. in accordance with UL Standard 67, and shall conform to the latest requirements of the National Electric Code and of NEMA Standard PB 1, Type 1, Class 1, unless otherwise indicated to meet environmental conditions at installed locations.

C. Directory Frame: Metal with plastic cover, mounted inside each panelboard door.

D. Bus: Hard drawn copper of 98 percent conductivity meet UL 67 temperature rise limits, and have a current density of 1000 amperes per square inch. Bus bars shall be sequenced-phased, and rigidly supported by high impact resistant, insulated bus supporting assemblies to prevent vibration or short circuits. Solderless terminations shall be suitable for copper UL listed wire or cable and shall be tested and listed in conjunction with appropriate UL standards.

1. Phase bus bars shall be silver plated copper or tin plated copper.
2. Neutral bus bar shall be copper or plated copper, and insulated from panelboard.
3. Capacity as indicated on Drawings, or equal to or greater than the panelboard OCPD.
4. Ground and neutral buses provided with mechanical connectors; one connector for each pole of panel.

E. Main and Neutral Lugs: Compression type.

1. The neutral bar shall be fully rated and capable of being located in either corner of the enclosure at the line end to facilitate conductor termination and shall be insulated from panelboard. Provide 200% rated neutral for panelboards supplying power to non-Linear loads.

F. Equipment Ground Bus: Ground bus shall be copper, fully rated, and adequate for feeder and branch-circuit equipment ground conductors with 25% additional space for future conditions. Lugs shall be sized to accommodate grounding conductors.

1. The ground bus shall be securely bonded to the cabinet and shall be separate from the neutral bus.

2. The number of terminations shall be equal to the number of poles in the panelboard.
3. The ground bus bar shall be structurally integral to the panelboard, or attached to the panelboard with a bolt, nut, and lock washer.

    a. If ground bus bar is mounted to enclosure with screw threads only, (i.e. tapped blind hole), a separate bolted ground lug shall be installed on the panelboard and bonded to the ground bus bar.

        1. Bond conductor shall have same current carrying capacity as the largest equipment grounding conductor terminated to the ground bus bar.

G. Short circuit rating: Panelboards shall be fully rated in AIC, see Drawings for AIC rating. Minimum: 10,000 AIC at 208V and 14,000 AIC at 480V.

H. Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the overcurrent protective device ampere ratings indicated for future installation of devices.

I. Include the following special features for panelboards.

1. Hinged Front Door in Door Construction: Entire front trim hinged to box with standard door within hinged trim cover (One piece front with two doors). The smaller door, when open, provides access to device handles and rating labels and shall be lockable. The larger door, when open, provides access to conductors and wiring terminals. Door hinges shall be continuous piano hinges which are welded to the door(s) and bolt on front.

    a. All door hinges shall be concealed.

2. Channel/Wiring Space: Shall be four (4) inches wide for power feeders up to and including 100 amperes, six (6) inches wide for power feeders over 100 amperes and up to and including 225 amperes, and eight (8) inches wide for power feeders over 225 amperes and up to 600 amperes.
3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and floor.
4. Subfeed: Overcurrent protective device or lug provision.

J. Doors shall have flush type cylinder locks and catches. All locks in a project shall be keyed alike, and 2 keys shall be furnished with each lock.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, UL 489, FS W-C-375 and the following requirements.

1. Molded case
2. Bolt-on breaker type with preassembled captive screw. Stab-in and plug-in types are not acceptable
3. Quick make, quick break connections with mechanical trip free switching mechanism
4. Inverse time, thermal overcurrent trip
5. Instantaneous magnetic trip
6. Thermal trip calibrated for 40 deg C ambient temperature

7. Provide breakers with number of poles, voltage rating, current rating, and frame size as indicated on the drawings
8. Multiple circuit breakers shall have an internal, common trip mechanism
9. Trip-indicating feature
10. Single-pole breakers shall be full size modules
11. Two and three pole breakers shall be sized in multiples of a single-pole breaker
12. Branch circuits shall be connected to the individual circuit number, as indicated on the Drawing
13. UL marked as suitable for use with 75 deg C wire
14. Shunt Trip: Where indicated

B. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices and interrupting capacity rating to meet available fault current as indicated on the Drawings.

1. Minimum rating: 10,000 AIC.
2. Circuit breaker ratings shall be in accordance with the SCA/PDC study, FAA Order 6950.27.

C. Circuit Breakers, 200 A and Larger: Trip units interchangeable within frame size.

D. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

2.5 SURGE PROTECTIVE DEVICE FOR FEEDER AND BRANCH PANELS

A. Each individual branch and feeder panel shall have a Surge Protection Device (SPD) installed. The SPD shall be installed on a dedicate circuit. The SPD shall be located as close as possible to the panel board with the wires being as short and straight as possible. Sharp bend shall be avoided. The enclosure door shall include indicating lights to demonstrate that each suppression device is functional. Each suppression device within the arrester shall be replaceable as a unit. Indoor arresters shall come with a NEMA 12 enclosure. Arresters shall be tested in accordance with ANSI/IEEE C62.11. In addition the arrester shall meet the following FAA-STD-019E requirement:

Modes of protection: L-N, L-L, L-G
Peak Surge Current: 3KA with 8/20 usec current impulse
Clamping Voltage: 475V L-N, L-G, 775V L-L for 120/208V system
Clamping Voltage: 775V L-N, L-G, 1275V L-L for 277/480V system

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with manufacturer's requirements in accordance with the direction of the COR. Install to withstand forces for the UBC Seismic Zone indicated in Section 16050, "Basic Electrical Materials and Methods."

3.2 INSTALLATION

A. Install panelboards and accessory items according to NEMA PB 1.1.

B. Mounting Heights, top of trim: 72 inches above finished floor, unless otherwise indicated.

C. Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.

D. Circuit Directory: Type directory to include installed circuit loads after balancing panelboard loads. The directory shall be arranged so that typed entries simulate circuit breaker positions in the panelboard. Obtain approval of the COR before installing.

E. Install filler plates in unused spaces.

F. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch GRC (Galvanized Rigid Conduit,) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

G. Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in, Section 16195 "Electrical Identification."

B. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws, as specified in Section 16195 "Electrical Identification." Provide panelboards with nameplates indicating the panel name, system voltage, and phase.

Example: Panel B-A222-A
208 Y/120 V, 3 Phase, 4 Wire

3.4 GROUNDING

A. Make equipment grounding connections for panelboards, and in accordance with, Section 16452 "Grounding."

B. Provide ground continuity to main electrical ground bus.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.6 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.
2. Make continuity tests of each circuit.

B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA, ATS, and Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

C. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform of operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

D. Electrical tests: Include the following items performed in accordance with manufacturer's instruction:

1. Perform pole to pole and pole to ground and to neutral insulation resistance tests with 500 volt DC megger. Insulation resistance shall be minimum of 50 megohms. Perform test with breakers mounted, in the ON position, and not connected to external circuits.
2. Ground resistance test on equipment ground connections.
3. Test main and sub-feed overcurrent protective devices.

3.7 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.8 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt and debris. Touch up scratches and marred finishes to match original finish.

3.9 COMMISSIONING

A. Balancing Loads: After Substantial Completion, conduct load-balancing measurements and circuit changes as follows:

1. Perform measurements during period of normal working load as advised by the COR.
2. Perform load-balancing circuit changes outside the normal occupancy/working schedule of the facility. Make special arrangements with COR to avoid disrupting critical 24-hour services such as FAA communications equipment and on-line data processing, computing, transmitting, and receiving equipment.
3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
4. After load balancing, modify identifications of relocated branch circuit conductors to comply with requirements of Section 16195 “Electrical Identification.” Revise record drawings to show modifications.
5. Tolerance: Difference between phase loads exceeding 20 percent at any one panelboard is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

END OF SECTION 16470

SECTION 16476

DISCONNECTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes individually mounted switches and circuit breakers used for the following:

1. Feeder and equipment disconnect switches.
2. Feeder overcurrent protection.
3. Motor disconnected switches.
4. Enclosed Circuit Breakers.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. Federal Aviation Administration (FAA)

1. C-1217f — Electrical Work, Interior.
2. STD-019e — Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities.

B. Federal Specifications (FS)

1. W-C-375 — Circuit Breakers, Molded Case; Branch Circuit and Service.

C. International Electrical Testing Association (NETA)

1. ATS — Acceptance Testing Specification for Electric Power Distribution Equipment and Systems.

D. National Electrical Manufacturer Association (NEMA)

1. KS 1 — Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
2. AB1 — Molded Case Circuit Breakers and Molded Case Switches
3. FU 1 — Low Voltage Cartridge Fuses

E. National Fire Protection Association (NFPA)

1. 70 — National Electrical Code (NEC)

F. Occupational Safety and Health Administration (OSHA)

1. 29CFR 1910.7 Definitions and requirements for a Nationally Recognized Testing Laboratory (NRTL).

G. Underwriters Laboratories (UL)

1. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.

1.3 SUBMITTALS

A. Product Data for switches, circuit breakers, and accessories specified in this Section. Include the following:

1. Descriptive data and time-current curves.
2. Let-through current curves for circuit breakers with current-limiting characteristics.
3. Coordination charts and tables and related data.

B. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

C. Field test reports indicating and interpreting test results.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: In addition to the requirements specified in Division 1 Section "Quality Control," an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1910.7, or shall be a full member company of the International Electrical Testing Association (NETA).

1. Testing Agency's Field Supervisor: Person currently certified by NETA or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain disconnect switches and circuit breakers from one source and by a single manufacturer.

C. Comply with NFPA 70 for components and installation.

D. Listing and Labeling: Provide disconnect switches and circuit breakers specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

E. Single Source Responsibility: All enclosed switches and circuit breakers shall be the product of a single manufacturer and shall be coordinated with Government Furnished Equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 DISCONNECT SWITCHES

A. General: Switches shall be indicated the voltage and current ratings on the Drawings, and each shall be capable of interrupting the locked rotor current of the motor for which it is to be used. The locked rotor current will be assumed to be ten (10) times the full rated load current. Switches shall be the quick-make, quick-break type. Except for ground lugs which shall be bonded to the housing, parts shall be mounted on insulating bases to permit replacement of any part from the front of the switch. All current carrying parts shall be of high conductivity copper unless otherwise specified, and shall be designed to carry rated current without excessive heating. Switch contacts shall be silver tungsten or plated to minimize corrosion, pitting and oxidation and to assure suitable conductivity.

B. Enclosed, Non-fusible Switch: NEMA KS 1, Type HD, lockable handle, with 2 padlocks.

C. Enclosed, Fusible Switch, below 800 amperes: NEMA KS 1, Type HD, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable with 2 padlocks, and interlocked with cover in CLOSED position. Provide rejection type fuse clips with switches.

D. Enclosure: NEMA KS 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.

1. Outdoor Locations: Type 3R.
2. Other Wet or Damp Indoor Locations: Type 4.

E. Auxiliary Contacts: Provide additional contacts for equipment with variable frequency drives: one (1) normally open, one (1) normally closed.

2.3 ENCLOSED CIRCUIT BREAKERS

A. Enclosed, Molded-Case Circuit Breaker: NEMA AB 1, lockable handle, with 2 padlocks complying with FED SPEC W-C-375.

B. Characteristics: Interrupting rating, frame size, trip rating, number of poles, and auxiliary devices as indicated. Circuit breakers shall have a quick-make and quick-break toggle mechanism, inverse-time trip characteristics and shall be trip-free on overload or short-circuit. Automatic release shall be secured by bi-metallic thermal element releasing the mechanism latch. A magnetic armature shall be

provided to trip the breaker instantaneously for short-circuit currents above the overload range. Automatic tripping shall be indicated by a handle position between the manual OFF and ON positions.

C. Interchangeable Trips: circuit breakers, 200 amperes and larger, with trip units interchangeable within frame size.

D. Field-Adjustable Trips: circuit breakers, 400 amperes and larger, with adjustable, short-time and continuous-current settings.

E. Molded-Case Switch: Where indicated, molded-case circuit breaker without trip units.

F. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.

G. Shunt Trip: Where indicated.

H. Accessories: As indicated.

I. Enclosure: NEMA AB 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.

1. Outdoor Locations: Type 3R.
2. Other Wet or Damp Indoor Locations: Type 4.

J. Motor Disconnect: Provide each motor with a disconnecting means and a manually operated switch as shown on the Drawings or when required by NFPA 70.

1. Single phase motors: Provide a single-pole or double pole toggle switch, rated only for AC, for motor capacities less than 30 amperes, providing that the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors. Enclosed safety switches shall conform with paragraph 2.3 B above.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

B. Install disconnected switches and circuit breakers in locations as indicated, according to manufacturer's written instructions. Install to withstand forces for the UBC Seismic Zone indicated in Section 16050, “Basic Electrical Materials and Methods.”

C. Install disconnected switches and circuit breakers level and plumb.

D. Install wiring between disconnect switches, circuit breakers, control, and indication devices.

E. Connect disconnect switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

F. Identify each disconnect switch and circuit breaker according to requirements specified in Section 16195.

3.2 FIELD QUALITY CONTROL

A. Testing: After installing disconnect switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for disconnect switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

B. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.3 ADJUSTING

A. Set field-adjustable disconnected switches and circuit-breaker trip ranges as indicated.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.

END OF SECTION 16476

SECTION 16481

MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes AC motor control devices rated 600 V and below that are supplied as an integral part of motor/controller packages.

B. Overcurrent protective devices (OCPD) and disconnect switches used with motor controllers are specified in Sections 16470 "Panelboards," and 16476 "Disconnects."

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. American Society of Testing and Materials (ASTM)

1. E699 Practice for Criteria For Evaluation of Agencies Involved Testing Quality Assurance, and Evaluating Building Components in Accordance with Test Methods Promulgated by ASTM Committee.

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior
2. STD-019e Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities

C. International Electrical Testing Association (NETA)

1. ATS Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

D. National Electrical Manufacturer Association (NEMA)

1. ICS 2 Standard for Industrial Control Devices, Controllers and Assemblies
2. 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
3. FCS 2 Industrial Control and Systems Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC

E. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

F. Occupational Safety and Health Administration (OSHA)

1. 29CFR 1910.7 Definitions and requirements for a Nationally Recognized Testing Laboratory (NRTL)

G. Underwriters Laboratories (UL)

1. 486A Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors.
2. 489 Standard for Safety Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
3. 508 Electrical Industrial Control Equipment

1.3 DEFINITIONS

A. Motor Controller: A device that controls, protects, and energizes an electric motor, and where required, controls its speed or the torque or power delivered by it.

1.4 SUBMITTALS

A. Product data for products shall be specified in this Section. Include dimensions, ratings, and data on features and components.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Maintenance Data for products to be included in Operating and Maintenance Manual specified in Division 1 and Section 16050 "Basic Electrical Materials and Methods."

D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suit actual motor nameplate full-load currents.

E. Qualification Data for Field Testing Agency: Certificates, signed by Contractor, certifying that agency complies with requirements specified in "Quality Assurance" Article below.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide solid-state, reduced-voltage and solid-state, variable-speed controllers from manufacturers regularly engaged in the manufacture of equipment of the types and capacities indicated, with such products in satisfactory use in similar service for not less than 5 years. Manufacturer must also maintain, within 100 miles of the project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Field Testing Agency Qualifications: An independent testing agency with experience and capability to satisfactorily conduct testing indicated without delaying the Work. Evaluation criteria shall be according to ASTM E 699.

C. Components and Installation: NFPA 70 "National Electrical Code."
D. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

E. NEMA Compliance: NEMA ICS 2, "Industrial Control Devices, Controllers and Assemblies."

F. UL Compliance: UL 508, "Electric Industrial Control Equipment."

G. Single-Source Responsibility: Obtain similar motor-control devices from a single manufacturer.

1.6 COORDINATION

A. General: Coordinate features of controllers and control devices with pilot devices and control circuits provided in Section 15975.

1.7 EXTRA MATERIALS

A. Spare Fuses and Pilot Light Indicating Lamps: Furnish one spare for every 5 installed units, but not less than one set of 3 of each kind.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 MOTOR CONTROLLERS, GENERAL

A. Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, the duty cycle of the motor, drive, and load, and the pilot device, and control circuit affecting controller functions. Provide controllers that are horsepower rated to suit the motor controlled and are of the manual reset type.

B. Contacts shall open each ungrounded connection to the motor.

C. Overload Relays: Motors, 1/8 horsepower or larger, shall have overload protection in each phase, or other equally rated method in accordance with NFPA 70. Ambient-compensated type with inverse-time- current characteristic. Provide with heaters or sensors matched to nameplate full-load current of the specific motor to which connected with appropriate adjustment for duty cycle.

1. Provide with reset button in an accessible location.

D. Enclosures: For individually mounted motor controllers and control devices, comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)." Provide enclosures suitable for the environmental conditions at the controller location. Provide NEMA Type 1 enclosures except as otherwise indicated.

2.3 MAGNETIC MOTOR CONTROLLERS

D. Description: Provide full-voltage, non-reversing, across-the-line, magnetic controller, horsepower rated, tested and labeled at NEMA size indicated on the drawings, with field replaceable main contacts, external manual resets, ambient compensated melting-alloy overload protection in all phases and low voltage release and the following accessories.

1. Auxiliary contacts: Two normally open and two normally closed contacts;
2. Pilot lights: Start-stop; and
3. Three position "Hand-Off-Automatic" switch.

E. Each 3-phase magnetic motor controller shall provide reversal and phase loss protection. Protective device shall cause controller to open upon loss of any one phase or reversal of phases.

F. Control Circuit: Provide control power transformer with 120 volt AC secondary holding coil with fused primary and secondary integral with controller where no other supply of 120 V control power to controller is indicated. Provide control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

G. Combination Controller: Provide combination motor controller complete with enclosure, disconnect operator with external handle, motor circuit protector, controller, controls, and wiring. Fabricated by one manufacturer and factory assembled, wired, and tested. Provide motor circuit protector in accordance with UL 489; molded-case circuit-breaker type with magnetic-only trip element calibrated to coordinate with the actual locked-rotor current of the connected motor and the controller overload relays. Provide breakers that are factory assembled with the controller, interlocked with unit cover or door, and arranged to disconnect the controller. Provide motor-circuit protectors with field-adjustable trip elements. Controller shall be UL 508 tested and listed to withstand 100,000 amperes RMS symmetrical fault current at 480 volts.

H. Enhanced-Protection Overload Relay: Provide overload relays with NEMA Class 10 tripping characteristics where indicated. Select to protect motor against voltage unbalance and single phasing.

2.6 SOLID-STATE, VARIABLE-SPEED MOTOR CONTROLLERS

A. General: See Section 15171, “Variable Frequency Drives.”

2.7 AUXILIARY CONTROL DEVICES

A. General: Factory installed in controller enclosure except as otherwise indicated. Where separately mounted, provide NEMA 1 enclosure except as otherwise indicated.

B. Push-button Stations, Pilot Lights, and Selector Switches: Heavy- duty type.

C. Stop and Lockout Push-button Station: Momentary-break push-button station with a factory-applied hasp arranged so a padlock can be used to lock the push-button in the depressed position with the control circuit open.

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

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Current Sensors: Rated to suit application.

G. Phase-Failure and under voltage relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable under voltage setting.

H. Current-Sensing, Phase-Failure Relay: Solid-state sensing circuit with isolated contacts for hard-wired connection. Arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with manufacturer's requirements in accordance with the direction of the COR.

3.2 APPLICATIONS

A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.

D. Use magnetic starters for 3-phase motors.

E. Push-button Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.

F. Hand-Off-Automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

3.3 INSTALLATION

A. Install independently mounted motor-control devices according to manufacturer's written instructions.

B. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components, including the pre-testing and adjustment of solid-state controllers.

C. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.

D. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks conforming to Section 16050 "Basic Electrical Materials and Methods."

3.4 IDENTIFICATION

A. Identify motor-control components and control wiring according to Section 16195 "Electrical Identification."

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Section 16120 "Wires and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic control devices where available.

1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.
2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals including screws and bolts shall be according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing.

B. Testing: After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
2. Testing Equipment: Use instruments bearing records of calibration within 3 months of testing.
3. Provide two (2) weeks advance notice to the COR prior to testing and schedule test at least one (1) week in advance of the test commencement.

C. Pretesting: On completing installation of the system, perform the following preparations for tests:

1. Make insulation resistance tests of conducting parts of motor control components; and of connecting supply, feeder, and control circuits. Use test equipment and methods recommended by the manufacturer for devices containing solid-state components.

2. Make continuity tests of circuits.
3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
4. Provide manufacturer's instructions for installation and testing of motor control devices to test personnel.

D. Visual and mechanical inspection: Include the following inspections and related work.

1. Motor-Control Device Ratings and Settings: Verify that ratings and settings as installed are appropriate for final loads and final system arrangement and parameters. Recommend final protective-device ratings and settings where differences are found. Use accepted revised ratings or settings to make the final system adjustments. Prepare and submit the load current and overload relay heater list.
2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current project drawings.
3. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instructions.
4. Check tightness of electrical connections of devices with calibrated torque wrench. Use manufacturer's recommended torque values.
5. Clean devices using manufacturer's approved methods and materials.
6. Verify proper fuse types and ratings in fusible devices.

E. Electrical Tests: Perform the following in accordance with manufacturer's instructions:

1. Insulation resistance test of motor control devices conducting parts to the extent permitted by the manufacturer's instructions. Insulation resistance less than 100 megohms is not acceptable.
2. Use primary current injection to check performance characteristics of motor-circuit protectors and for overload relays of controllers for motors 15 horsepower and larger. Trip characteristics not within manufacturer's published time-current tolerances are not acceptable.
3. Make adjustments for final settings of adjustable-trip devices.
4. Test auxiliary protective features such as loss of phase, phase unbalance and undervoltage to verify operation.
5. Check for improper voltages at terminals in controllers that have external control wiring when controller disconnect is opened. Any voltage over 30 V is unacceptable.

F. Remove and replace malfunctioning units with new units, and retest.

3.8 CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.9 DEMONSTRATION

A. Training: Engage a factory-authorized service representative to demonstrate solid-state and variable-speed controllers and train Government’s maintenance personnel.

1. Conduct a minimum of 4 hours of training in operation, maintenance and related equipment.

END OF SECTION 16481

SECTION 16515

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes interior lighting fixtures, lamps, ballasts, emergency lighting units, and accessories.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

1. C62.41 Recommended Practice on Surge Voltage in Low-Voltage AC Power Circuits
2. C82.2 Fluorescent Lamp Ballasts - Methods of Measurement

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior
2. STD-019e Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities

C. Federal Communications Commission (FCC)

1. Part 15, Subpart J

D. Institute of Electrical and Electronics Engineers (IEEE)

1. C62.41 IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

E. Military Standards

1. MIL-STD-461 Requirements for the Control of Electromagnetic Interference, emission and susceptibility

F. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code (NEC)

G. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 - National Recognized Testing Laboratories (NRTL)

H. Uniform Building Code (UBC)

I. Underwriters Laboratories (UL)

1. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
2. 542 Lampholders, Starters, and Starter Holders for Fluorescent Lamps.
3. 924 Emergency Lighting and Power Equipment
4. 935 Fluorescent Lamps and Ballasts
5. 1570 Fluorescent Lighting Fixtures
6. Compact Fluorescent Lighting Fixtures and Ballasts

1.3 DEFINITIONS

A. Fixture: A complete lighting unit or exit sign. Fixtures include lamps and parts required to distribute the light, position and protect lamps, and connect lamps to the power supply.

B. Luminaries: Fixture.

C. Average Life: The time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

1.4 SUBMITTALS

A. Product data describing fixtures, lamps, and ballasts. Arrange product data for fixtures in order of fixture designation. Include data on features and accessories and the following information:

1. Outline drawings of fixtures indicating dimensions and principal features.
2. Electrical ratings and photometric data with specified lamps and certified results of independent laboratory tests.

B. Product certifications signed by manufacturers of lighting fixtures certifying that their fixtures comply with specified requirements.

C. Shop drawings from manufactures detailing nonstandard fixtures and indicating dimensions, weights, methods of field assembly, components, features, accessories, supports, and seismic bracing.

D. Coordination drawings for fixtures mounted on, in, or above the ceiling indicating coordination with ceiling grids and other equipment installed in the same space.

1.5 QUALITY ASSURANCE

A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL.

B. Listing and Labeling: Provide fixtures and accessory components that are listed and labeled for their indicated use and installation conditions on the Project.

1. Special Listing and Labeling: Provide fixtures for use in damp or wet locations, underwater, and recessed in combustible construction that are specifically listed and labeled for such use. Provide fixtures for use in hazardous (classified) locations that are listed and labeled for the specific hazard.

2. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
3. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

C. Manufacturer Qualifications: Manufacturer shall have manufactured fixtures and ballasts similar to those indicated in this project for at least ten years.

D. Coordinate fixtures, mounting hardware, and trim with ceiling system and other items, including work of other trades, required to be mounted on ceiling or in ceiling space.

1.6 EXTRA MATERIALS

A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to the Government.

1. Lamps: 1 lamp for each 10 of each type and rating installed. Furnish at least 1 of each type.
3. Plastic Diffusers and Lenses: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
4. Ballasts: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
5. Filters: 1 filter for each 10 of each type and rating installed. Furnish at least 1 of each type.
6. Wire Guards: 1 for every 50 of each type installed. Furnish at least one of each type.

1.7 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty - Ballasts: Provide a written warranty signed by manufacturer and Installer agreeing to replace ballasts against defects in material or workmanship for a period of five years from the date of Substantial Completion. Defective ballasts shall be replaced within the warranty period at no cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 FIXTURES, GENERAL

A. Comply with the requirements specified in this specification and lighting fixture schedule indicated on the drawings.

B. The fixtures specified in the lighting fixture schedule on the Drawings establish a level of quality and appearance that any substituted fixtures must match or exceed. Substitutions for the specified fixtures will be reviewed by the Engineer for compliance and approval.

C. All lighting fixtures shall be UL approved and shall bear the UL label.

2.3 FIXTURE COMPONENTS, GENERAL.

A. Metal Parts: Free from burrs and sharp corners and edges.

B. Sheet Metal Components: Steel, except as indicated. Components are formed and supported to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.

1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: 0.125 inch minimum; except where greater thickness is indicated.

F. Fixture wiring shall be thermoplastic insulated copper, rated for 600 volts, in accordance with F.S. J-C-30 and the NEC.

G. Flexible metal conduit, minimum 3/8 inch nominal trade size is permitted.

H. Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) filters.

2.4 FLUORESCENT FIXTURES.

A. Fixtures conform to UL 1570, “Fluorescent Lighting Fixtures.”

B. Ballasts: Conform to UL 935, “Fluorescent-Lamp Ballasts.”

1. Certification: By Electrical Testing Laboratory (ETL).
2. Labeling: By Certified Ballast Manufacturers Association (CBM).
3. Type: Class P. high-power factor type except as indicated otherwise.

a. Shall include inherent automatic thermal reset and fuse.
b. Shall be type for use in indoor or type 1, outdoor applications

4. Sound Rating: A rating, except as indicated otherwise.
5. Voltage: Match connected circuits.

C. Low Temperature Ballast Minimum Starting Temperature: Minus 0 degrees F.

D. Electronic Ballasts: Solid-state, full-light-output, energy-saving type compatible with T8 lamps. Conform to FCC regulations Part 15, Subpart J. for electromagnetic interference. Conform to ANSI C62.41, "Guide for Surge Voltages in Low-Voltage AC Power Circuits," Location Category A2, for resistance to voltage surges for normal and common modes.

1. Minimum Ballast Factor: 85 percent.
2. Minimum Power Factor: 90 percent.
3. Minimum Operating Frequency: 20,000 Hz.
4. Total Harmonic Distortion (THD) of Ballast Current: 10 percent or less
5. Average Input: The following is the average required wattage when tested according to ANSI C82.2, "Fluorescent Lamp Ballasts, and Methods of Measurement."

   a) 62 or less watts when operating two F32T8 lamps.
   b) 32 or less watts when operating one F32T8 lamp.
   c) 85 or less watts when operating three F32T8 lamps.

6. Ballasts shall operate the lamps in parallel.
7. Ballasts shall be fully encapsulated to ensure maximum thermal and structural integrity.

E. Dimming Ballasts: Solid state, full light output with dimming range of 100% to 10 % continuous light output. Conform to IEEE C62.41, "Guide for Surge Voltages in Low Voltage AC Power Circuits," Category A, for resistance to voltage surges.

1. Minimum Power Factor: 95 percent.
2. Minimum Operating Frequency: 20,000 hertz without visible flicker.
3. Maximum Crest Factor: 1.4.
4. Ballast Dimming Circuitry shall be class 2 and fully isolated from ballast input power.
5. Ballast shall maintain constant light output over operating ranges of 200 volts to 320 volts (277V ballasts) 60 Hz.
6. Ballast shall require no intermediate trimming controls between ballast and controlling device.
7. Ballast case temperature shall not exceed 25 degree C. temperature rise over 40 degree C. ambient.

F. Lamp holders shall have silver plated contacts, and shall conform to UL 542.

G. Recessed Fixtures: Recessed fluorescent fixtures shall have adjustable fittings to permit alignment with ceiling panels.

H. Suspended Fixtures: Pendant mounted fluorescent fixtures shall conform to FS W-F-414 and shall be types indicated on the Drawings.

2.5 COMPACT FLUORESCENT FIXTURE

A. Compact Fluorescent Lamps:
   a. Lamp life: 10000 hours.
   b. Color Temperature: 2700 – 4100 Kelvin degrees.

c. Color Rendering Index; 82
d. Lumen Maintenance: 83% – 87%.
e. Longer start and warm up time in low temperature
f. Lamp is not less than 13 watts
g. U-Bent fluorescent lamps are not acceptable.
h. Use electronic ballast

B. Compact Fluorescent Fixtures:
Per catalog called out from Lighting Fixture Schedule indicated on plan.

2.5 INCANDESCENT FIXTURES.

Not used

2.6 EMERGENCY FLUORESCENT POWER SUPPLY UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit factory mounted within fixture body. Comply with UL 924.

1. Test Switch and Light-Emitting Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
2. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum 10-year nominal life, with capacity to supply power to 2 lamps for 90 minutes at a minimum of 300 lumens per lamp output.
3. Charger: Fully automatic, solid-state, constant-current type.
4. Operation: Relay automatically energizes lamp from unit when normal supply circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamp, and battery is automatically recharged and floated on charger.
5. Emergency ballast shall be compatible with standard, energy saving, dimming, and electronic AC ballasts.
6. Unit shall be incorporated into a normally operating fixture such that it does not interfere with normal operation. Because this requires an unswitched source of power, an unswitched source of power must be provided for the switched fixture.

2.7 EXIT SIGNS.

A. Conform to UL 924 “Emergency Lighting and Power Equipment,” and the following:

1. Sign Colors: Conform to local code.
2. Minimum Height of Letters: Conform to local code.
3. Arrows: Include as indicated.
4. Lamps for AC Operation: Light emitting diode (LED) array.

2.8 LAMPS

A. Furnish lamps for all fixtures in accordance with the lighting fixture schedule.

B. Conform to ANSI C78 series applicable to each type of lamp.

C. Fluorescent Color Temperature and Minimum Color-Rendering Index (CRI): 3500 K and 85 CRI, except as otherwise indicated.

2.9 FINISHES

A. Manufacturer's standard finish applied over corrosion-resistant treatment or primer, free of streaks, runs, stains, blisters, and similar defects. Remove fixtures showing evidence of corrosion during project warranty period and replace with new fixtures.

PART 3 - EXECUTION

3.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

3.2 INSTALLATION

A. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved Shop Drawings.

B. Install fixtures and support system to withstand forces for the UBC Seismic Zone indicated in Section 16050, "Basic Electrical Materials and Methods."

C. Support for Recessed and Semi-recessed Grid-Type Fluorescent Fixtures: Units shall not be solely supported from suspended ceiling support system. Install ceiling support system rods or wires at a minimum of 4 rods or wires for each fixture, located not more than 3 inches from fixture corners. In addition, each fixture shall be supported at each corner, with 12 gage drop ceiling hanger wire.

1. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner.
2. Fixtures Smaller than Ceiling Grid: Install a minimum of 4 rods or wires for each fixture at corner of ceiling grid where fixture is located. Do not support fixtures by ceiling acoustical panels.
3. Fixtures of Sizes Less than Ceiling Grid: Center in acoustical panel. Support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

D. Lamping: Lamp units according to manufacturer's instructions. For lamps are on the dimming circuits, they must be operated at full intensity for 100 hours before dimming per dimming ballast's manufacturer's recommendations.

E. Ground lightning fixtures in accordance with Section 16452, "Grounding." Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A. Fixtures shall be grounded in accordance with FAA C-1217f, paragraph 4.4.5.2.

F. External bonding jumpers are not required across lighting fixture flexible conduit.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Damaged fixtures and components shall be replaced.

B. Give advance notice of dates and times for field tests.

C. Provide instruments to make and record test results.

D. Tests: Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source. Interrupt electrical energy to demonstrate proper operation of emergency lighting installation. Include the following in tests of emergency lighting battery system.

1. Duration of supply.
2. Low battery voltage shut-down.
3. Normal transfer to battery source and retransfer to normal.
4. Low supply voltage transfer.

All fixtures shall be energized upon completion of installation for a period of 72 hours, upon which contractor shall replace any lamps or ballasts which are not operating properly.

E. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

F. Report results of tests.

G. Replace fixtures that show evidence of corrosion during Project warranty period.

3.4 ADJUSTING AND CLEANING

A. Clean fixtures after installation. Use methods and materials recommended by manufacturer.

B. Adjust amiable fixtures in the presence of the COR to provide required light intensities.

END OF SECTION 16515

SECTION 16515

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes interior lighting fixtures, lamps, ballasts, emergency lighting units, and accessories.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

1. C62.41 Recommended Practice on Surge Voltage in Low-Voltage AC Power Circuits
2. C82.2 Fluorescent Lamp Ballasts - Methods of Measurement

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior
2. STD-019e Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities

C. Federal Communications Commission (FCC)

1. Part 15, Subpart J

D. Institute of Electrical and Electronics Engineers (IEEE)

1. C62.41 IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

E. Military Standards

1. MIL-STD-461 Requirements for the Control of Electromagnetic Interference, emission and susceptibility

F. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code (NEC)

G. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 - National Recognized Testing Laboratories (NRTL)

H. Uniform Building Code (UBC)

I. Underwriters Laboratories (UL)

1. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
2. 542 Lampholders, Starters, and Starter Holders for Fluorescent Lamps.
3. 924 Emergency Lighting and Power Equipment
4. 935 Fluorescent Lamps and Ballasts
5. 1570 Fluorescent Lighting Fixtures
6. Compact Fluorescent Lighting Fixtures and Ballasts

1.3 DEFINITIONS

A. Fixture: A complete lighting unit or exit sign. Fixtures include lamps and parts required to distribute the light, position and protect lamps, and connect lamps to the power supply.

B. Luminaries: Fixture.

C. Average Life: The time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

1.4 SUBMITTALS

A. Product data describing fixtures, lamps, and ballasts. Arrange product data for fixtures in order of fixture designation. Include data on features and accessories and the following information:

1. Outline drawings of fixtures indicating dimensions and principal features.
2. Electrical ratings and photometric data with specified lamps and certified results of independent laboratory tests.

B. Product certifications signed by manufacturers of lighting fixtures certifying that their fixtures comply with specified requirements.

C. Shop drawings from manufactures detailing nonstandard fixtures and indicating dimensions, weights, methods of field assembly, components, features, accessories, supports, and seismic bracing.

D. Coordination drawings for fixtures mounted on, in, or above the ceiling indicating coordination with ceiling grids and other equipment installed in the same space.

1.5 QUALITY ASSURANCE

A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL.

B. Listing and Labeling: Provide fixtures and accessory components that are listed and labeled for their indicated use and installation conditions on the Project.

1. Special Listing and Labeling: Provide fixtures for use in damp or wet locations, underwater, and recessed in combustible construction that are specifically listed and labeled for such use. Provide fixtures for use in hazardous (classified) locations that are listed and labeled for the specific hazard.

2. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
3. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

C. Manufacturer Qualifications: Manufacturer shall have manufactured fixtures and ballasts similar to those indicated in this project for at least ten years.

D. Coordinate fixtures, mounting hardware, and trim with ceiling system and other items, including work of other trades, required to be mounted on ceiling or in ceiling space.

1.6 EXTRA MATERIALS

A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to the Government.

1. Lamps: 1 lamp for each 10 of each type and rating installed. Furnish at least 1 of each type.
3. Plastic Diffusers and Lenses: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
4. Ballasts: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
5. Filters: 1 filter for each 10 of each type and rating installed. Furnish at least 1 of each type.
6. Wire Guards: 1 for every 50 of each type installed. Furnish at least one of each type.

1.7 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty - Ballasts: Provide a written warranty signed by manufacturer and Installer agreeing to replace ballasts against defects in material or workmanship for a period of five years from the date of Substantial Completion. Defective ballasts shall be replaced within the warranty period at no cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

2.2 FIXTURES, GENERAL

A. Comply with the requirements specified in this specification and lighting fixture schedule indicated on the drawings.

B. The fixtures specified in the lighting fixture schedule on the Drawings establish a level of quality and appearance that any substituted fixtures must match or exceed. Substitutions for the specified fixtures will be reviewed by the Engineer for compliance and approval.

C. All lighting fixtures shall be UL approved and shall bear the UL label.

2.3 FIXTURE COMPONENTS, GENERAL.

A. Metal Parts: Free from burrs and sharp corners and edges.

B. Sheet Metal Components: Steel, except as indicated. Components are formed and supported to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.

1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: 0.125 inch minimum; except where greater thickness is indicated.

F. Fixture wiring shall be thermoplastic insulated copper, rated for 600 volts, in accordance with F.S. J-C-30 and the NEC.

G. Flexible metal conduit, minimum 3/8 inch nominal trade size is permitted.

H. Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) filters.

2.4 FLUORESCENT FIXTURES.

A. Fixtures conform to UL 1570, “Fluorescent Lighting Fixtures.”

B. Ballasts: Conform to UL 935, “Fluorescent-Lamp Ballasts.”

1. Certification: By Electrical Testing Laboratory (ETL).
2. Labeling: By Certified Ballast Manufacturers Association (CBM).
3. Type: Class P. high-power factor type except as indicated otherwise.

a. Shall include inherent automatic thermal reset and fuse.
b. Shall be type for use in indoor or type 1, outdoor applications

4. Sound Rating: A rating, except as indicated otherwise.
5. Voltage: Match connected circuits.

C. Low Temperature Ballast Minimum Starting Temperature: Minus 0 degrees F.

D. Manuafacturers must meet all of the following. All evaluation will be based upon manufacturer published data. Utilities can require independent verification of performance data for program participation.

1. Electronic ballasts covered by this specification shall meet ANSI C82.11-1993 (High Frequency Fluorescent Lamp Ballasts).
2. All ballasts shall be Underwriters Laboratory (UL 935) listed, Class P, Type 1 Outdoor. CSA Certified where applicable.
3. The manufacturer shall provide written warranty against defects in material or workmanship, including replacement, for five years from date of manufacture.
4. Ballast shall have a Class A sound rating.
5. Ballast shall be a high frequency electronic type and operate lamps at a frequency above 42 KHz to avoid interference with Infrared devices.
6. Ballast shall comply with FCC Part 18 Non-Consumer Equipment, Class A for EMI (Conducted) and (Radiated).
7. Ballast shall not contain any PCB's (Polycholorinated Biphenyl).
8. Ballasts for T5 and T5HO lamps shall be "Program Start" with end-of-life detection.
9. The power factor (PF) for all ballasts shall be greater than 95%.
10. Total harmonic distortion (THD) of the input current shall not exceed 10% of the fundamental 60 Hz current for low and normal light output ballasts. 20% of the fundamental 60 Hz for high light output ballasts (ballast factor greater than 1.0)

11. Ballasts shall operate the lamps in parallel.
12. Ballasts shall be fully encapsulated to ensure maximum thermal and structural integrity.

E. Dimming Ballasts: Solid state, full light output with dimming range of 100% to 10 % continuous light output. Conform to IEEE C62.41, "Guide for Surge Voltages in Low Voltage AC Power Circuits," Category A, for resistance to voltage surges.

1. Minimum Power Factor: 95 percent.
2. Minimum Operating Frequency: 20,000 hertz without visible flicker.
3. Maximum Crest Factor: 1.4.
4. Ballast Dimming Circuitry shall be class 2 and fully isolated from ballast input power.
5. Ballast shall maintain constant light output over operating ranges of 200 volts to 320 volts (277V ballasts) 60 Hz.
6. Ballast shall require no intermediate trimming controls between ballast and controlling device.
7. Ballast case temperature shall not exceed 25 degree C. temperature rise over 40 degree C. ambient.

F. Lamp holders shall have silver plated contacts, and shall conform to UL 542.

G. Recessed Fixtures: Recessed fluorescent fixtures shall have adjustable fittings to permit alignment with ceiling panels.

H. Suspended Fixtures: Pendant mounted fluorescent fixtures shall conform to FS W-F-414 and shall be types indicated on the Drawings.

2.5 COMPACT FLUORESCENT FIXTURE

A. Compact Fluorescent Lamps:
   a. Lamp life: 10000 hours.
   b. Color Temperature: 2700 – 4100 Kelvin degrees.
   c. Color Rendering Index; 82
   d. Lumen Maintenance: 83% – 87%.
   e. Longer start and warm up time in low temperature
   f. Lamp is not less than 13 watts
   g. U-Bent fluorescent lamps are not acceptable.
   h. Use electronic ballast

B. Compact Fluorescent Fixtures:
   Per catalog called out from Lighting Fixture Schedule indicated on plan.

2.5 INCANDESCENT FIXTURES.

Not used

2.6 EMERGENCY FLUORESCENT POWER SUPPLY UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit factory mounted within fixture body. Comply with UL 924.

1. Test Switch and Light-Emitting Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
2. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum 10-year nominal life, with capacity to supply power to 2 lamps for 90 minutes at a minimum of 300 lumens per lamp output.
3. Charger: Fully automatic, solid-state, constant-current type.
4. Operation: Relay automatically energizes lamp from unit when normal supply circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamp, and battery is automatically recharged and floated on charger.
5. Emergency ballast shall be compatible with standard, energy saving, dimming, and electronic AC ballasts.
6. Unit shall be incorporated into a normally operating fixture such that it does not interfere with normal operation. Because this requires an unswitched source of power, an unswitched source of power must be provided for the switched fixture.

2.7 EXIT SIGNS.

A. Conform to UL 924 “Emergency Lighting and Power Equipment,” and the following:

1. Sign Colors: Conform to local code.
2. Minimum Height of Letters: Conform to local code.
3. Arrows: Include as indicated.
4. Lamps for AC Operation: Light emitting diode (LED) array.

B. Internally Lighted Signs:

a. Lamps for AC operation: LED, 70,000 hours minimum rated lamp life.

b. Self powered exit sign (battery type): integral automatic charger in a self contained power pack.

- Battery: sealed, maintenance free nicked cadmium type.
- Charger: fully automatic, solid state type with sealed transfer relay.
- Operation: Relay automatically energizes lamp from battery when circuit voltage drop to 80 percent of nominal voltage or below. When nominal voltage is restored, relay disconnects lamps form battery, and battery is automatically recharged and floated on charger.
- Test push button: bush to test type in unit housing, simulated lost of normal power and demonstrates unit operability.
- LED indicator light: indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
- Remove test: switch in hand held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
- Integral self test: factory installed electronic device automatically initiates code required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.8 LAMPS

A. Furnish lamps for all fixtures in accordance with the lighting fixture schedule.

B. Conform to ANSI C78 series applicable to each type of lamp.

C. Fluorescent Lamp Color Temperature and Minimum Color-Rendering Index (CRI): 3500 K and 85 CRI, except as otherwise indicated.

D. T5 standard lamp, rated 28 watts, nominal length of 46 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

E. Compact fluorescent lamps: 4-pin, low mercury, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at 3 hours operation per start unless otherwise indicated.

2.9 FINISHES

A. Manufacturer's standard finish applied over corrosion-resistant treatment or primer, free of streaks, runs, stains, blisters, and similar defects. Remove fixtures showing evidence of corrosion during project warranty period and replace with new fixtures.

PART 3 - EXECUTION

3.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA STD-019e.

3.2 INSTALLATION

A. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved Shop Drawings.

B. Install fixtures and support system to withstand forces for the UBC Seismic Zone indicated in Section 16050, "Basic Electrical Materials and Methods."

C. Support for Recessed and Semi-recessed Grid-Type Fluorescent Fixtures: Units shall not be solely supported from suspended ceiling support system. Install ceiling support system rods or wires at a minimum of 4 rods or wires for each fixture, located not more than 3 inches from fixture corners. In addition, each fixture shall be supported at each corner, with 12 gage drop ceiling hanger wire.

1. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner.
2. Fixtures Smaller than Ceiling Grid: Install a minimum of 4 rods or wires for each fixture at corner of ceiling grid where fixture is located. Do not support fixtures by ceiling acoustical panels.
3. Fixtures of Sizes Less than Ceiling Grid: Center in acoustical panel. Support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

D. Lamping: Lamp units according to manufacturer's instructions. For lamps are on the dimming circuits, they must be operated at full intensity for 100 hours before dimming per dimming ballast's manufacturer's recommendations.

E. Ground lightning fixtures in accordance with Section 16452, "Grounding." Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A. Fixtures shall be grounded in accordance with FAA C-1217f, paragraph 4.4.5.2.

F. External bonding jumpers are not required across lighting fixture flexible conduit.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Damaged fixtures and components shall be replaced.

B. Give advance notice of dates and times for field tests.

C. Provide instruments to make and record test results.

D. Tests: Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source. Interrupt electrical energy to demonstrate proper operation of emergency lighting installation. Include the following in tests of emergency lighting battery system.

1. Duration of supply.
2. Low battery voltage shut-down.
3. Normal transfer to battery source and retransfer to normal.
4. Low supply voltage transfer.

All fixtures shall be energized upon completion of installation for a period of 72 hours, upon which contractor shall replace any lamps or ballasts which are not operating properly.

E. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

F. Report results of tests.

G. Replace fixtures that show evidence of corrosion during Project warranty period.

3.4 ADJUSTING AND CLEANING

A. Clean fixtures after installation. Use methods and materials recommended by manufacturer.

B. Adjust amiable fixtures in the presence of the COR to provide required light intensities.

END OF SECTION 16515

SECTION 16670

LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes lightning protection for buildings and associated structures and requirements for lightning protection system components.

B. Bond the existing bonding jumpers to the new roof metal objects.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. Federal Aviation Administration (FAA)

1. C-1217f — Electrical Work, Interior
2. STD-019e — Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities
3. Order 6950.19a — Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation.

B. National Fire Protection Association (NFPA)

1. 780 — Lightning Protection Code
2. 70 — National Electrical Code

C. National Institute of Standards and Technology (NIST)

D. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 — Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL).

D. Underwriters Laboratories (UL)

1. 96 — Lightning Protection Components
1. 96A — Installation Requirements for Lightning Protection Systems

1.3 SUBMITTALS

A. Product Data for each component specified. Include the following:

1. Roof adhesive data.

2. Decorative air terminal illustrations.

B. Shop Drawings detailing lightning protection system, including but not limited to air terminal locations, conductor routing and connections, bonding and grounding provisions. Include indications for use of raceway and data on how concealment requirements will be met.

C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by nationally recognized testing laboratory (NRTL) or trade association. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

E. Field inspection reports indicating compliance with specified requirements.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is certified by the Lightning Protection Institute as a Master Installer/Designer to install lightning protection system.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled by an organization concerned with product evaluations and that can determine compliance with appropriate standards for the current production of listed items.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

C. Conform to NFPA 780.

D. Conform to UL 96A and provide UL Master Label.

E. Conform to the most stringent requirements of the following standards.

1. LPI certification of system.
2. ETL Master Label indicating system complies with specified requirements.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components and building finish, in accordance with FAA Order 6950.19a.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Materials: All equipment must be UL approved and marked in accordance with UL procedures. All equipment must be new and of a design and construction to suit the application in accordance with UL 96A requirements. Bronze and stainless steel may be used for some components.

D. Secondary Conductors: Provide secondary or bonding conductors as indicated on drawings.

E. Hardware: Bonding devices, cable splicers, and miscellaneous connectors must be suitable for use with the installed conductor and must be copper or bronze with exothermic weld. Bolt pressure connections of secondary conductors may be acceptable. Cast or stamped crimp type fittings must not be used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of lightning protection System. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Installation must conform to UL standard 96A. Installer must provide an Underwriters' Laboratories Master Label for the facility.

B. Comply with UL 96A, NFPA 780, FAA C-1217f, FAA STD-019e and FAA Order 6950.19a.

C. Conform to the most stringent requirements when more than one standard is specified.

D. Conductor and conduit routing: Roof and down conductors must maintain a horizontal or downward course. No bend in a roof or down conductor must form an included angle of less than 90 degrees, nor must it have a bend radius of less than 8 inches. Conductors must be routed external to buildings and 6 feet or more from power or signal conductors.

E. Down conductor terminations: Down conductors used to ground air terminals and roof conductors must terminate on buried ground rods eighteen (18) inches vertically below ground level, and from 2 feet to 6 feet outside the foundation or exterior footing of the building. Down conductors must be connected to the ground rods by exothermic welding. Provide number of down conductors indicated on drawings.

F. Route down conductors outside of building facade in PVC conduit. Submit system plan which indicates exact location of down conductors, as well as intended equipment locations, to engineer for approval prior to installation.

G. Notify COR at least 24 hours before concealing lightning protection system components.

H. Air Terminal attachment: All air terminals must be secured against overturning either by attachment to the object to be protected, or by means of braces that are permanently and rigidly attached to the building.

I. Metallic bodies subject to induced charges: Metallic bodies, on or below roof level, that are subject to induced charges from lightning include roof drains, plumbing vents, metal coping, metal flashing, gutters, downspouts, small metal wall vents, door and window frames, metal balcony railings, and generally, any isolated metallic body within 6 feet of an exposed lightning protection system element. These metallic bodies must be bonded to the lightning protection system using UL approved splicers, fittings, and conductors. Conductors used for bonding these metallic bodies must be Class I secondary conductors in accordance with NFPA 780.

J. Metallic bodies subject to direct lightning discharge: Metallic bodies on roofs subject to direct lightning discharge are generally any large metallic body whose size causes it to protrude beyond the zone of protection of the installed air terminals. This includes exhaust fans, ladders, railings, and roof hatches. When these metallic bodies have a metal thickness of 3/16 inches or greater, they must be bonded to the nearest main lightning protection system conductor with UL approved fittings and conductors meeting the requirements of NFPA 780. These bonding fittings must provide surfaces of not less than 3 square inches. Provisions must be made to prevent corrosive effects introduced by galvanic action of dissimilar metals at bonding points. If the metal parts of these units are less than 3/16 inches thick, additional approved air terminals, conductors, and fittings, providing a two-way path to ground from the air terminals, must be installed.

K. Hydraulically crimped connections are not acceptable. Only exothermic welds are acceptable.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such materials.

B. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Periodic Inspections: Provide the services of a qualified inspector to perform periodic inspections during construction and at its completion, according to LPI-177.

B. UL Inspection: Apply for inspection by UL as required for UL master labeling of system.

C. ETL Inspection: Provide the services of ETL to inspect completed system for conformance with specified requirements.

3.5. TESTING

A. Upon completion of installation of lightning protection system, test resistance-to-ground with resistance tester. Where tests show resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by treating soil proximity to ground rods with sodium chloride, copper sulfate, or magnesium. Then retest to demonstrate compliance.

END OF SECTION 16670

SECTION 16740

VOICE/DATA HORIZONTAL CABLING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:

1. Voice/network cable distribution system within the building. The system shall include cable, connected blocks, patch panels, grounding circuits, modular jacks, wall plates, cable tray and a network equipment rack. The distribution system and individual components shall meet Category 6 specifications.
2. Network equipment rack located in Telco/Electrical room as shown on the plans. The network equipment rack shall incorporate horizontal and vertical cable management methods and rack mounted Category 6 patch panels for the station cable..
3. Each data, voice, and auxiliary outlet jack shall be connected to a patch panel jack in the respective network equipment rack by one Category 6 unshielded twisted pair (UTP) cable with all 4 pairs terminated on each end using T568-B pin/pair layout.
4. The Cabling System shall support analog and digital voice applications, data, and local area networks (LAN) on a common cabling platform.

B. Prohibited Work: Cable shall not be spliced.

1.2 RELATED SECTIONS

A. Section 16050 “Basic Electrical Materials and Methods.”

B. Section 16100 “Raceways, Boxes and Cabinets.”

C. Section 16190 “Supporting Devices.”

D. Section 16195 “Electrical Identification.”

1.3 REFERENCE SPECIFICATIONS, STANDARDS AND CODES

A. Comply with requirements specified in Section 16700.

B. Electronic Industries Association Telecommunications Industry Association

1. EIA/TIA-568-B - Commercial building Telecommunications Cabling Standard, October 6, 1995
2. EIA/TIA-569 - Commercial Building Standard for Telecommunications Pathways and Spaces, October 15, 1990
3. EIA/TIA-606 - Administration Standard for the Telecommunication Infrastructure, January 28, 1993
4. EIA/TIA-607 - Commercial Building Grounding and Bonding Requirements for Telecommunications, August 1, 1994
5. EIA/TIA TSB-67 - Link Performance Transmission Specification for Field Testing of Unshielded Twisted Pair Cabling, November 3, 1995
6. National Electric Code (NEC), 2005.

C. Building Industry Consulting Society International (BICSI) Telecommunications Distribution Methods Manual (TDMM), 2003 Edition.

1.4 SUBMITTALS

A. Submit the following in compliance with requirements of Division 1 and Section 16700.

B. Product data: Include data sheets, parts lists, part descriptions and installation instructions.

C. Shop drawings: Show connection types and locations, installation requirements, and coordination with related work. Note restrictions regarding splices as specified above.

D. Test Plan: Provide a test plan to certify that the system meets Category 6 standards as installed.

E. Certificate of compliance with EIA/TIA Category 6 criteria from an independent laboratory:

1. UTP Cable
2. Connected Blocks
3. Outlet Jacks
4. Patch cables.
5. Patch Panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products listed in this section represent the required features and level of quality to meet system operational requirements. Subject to compliance with specified requirements, provide items manufactured by one of the following:

1. Leviton (preferred).
2. Cooper B-Line
3. Middle Atlantic
4. Ortronics (preferred)

2.2 PRODUCTS AND ACCESSORIES

A. All Category 6 cables shall conform to or exceed the EIA/TIA 568-B Commercial Building Wiring Standard, published 2001. Cable shall support 100BaseT as a minimum.

B. All Nonplenum Category 6 UTP cables shall be composed of 24 AWG solid copper conductors, dual insulated with Polyolefin. The insulated conductors shall be twisted into pairs and jacketed with Polyvinyl Chloride (PVC)

C. All plenum Category 6 UTP cables shall be composed of 24 AWG solid copper conductors, with dual FRPO/FEP insulation and Flame-arrest jacket. All station cable installed from wall jacks to patch panels shall be plenum rated.

D. The cable shall meet or exceed the Electrical Specifications listed below:

Maximum DC Resistance			9.38 Ohms/100 m
Mutual Capacitance @ 1.0 Khz			4.92 nF/100 m
Maximum Capacitance Unbalance			330pF/100 m
Attenuation (dB/100 m)	@	1.0 Mhz	2.0 db
	@	4.0 Mhz	4.1 db
	@	10.0 Mhz	6.5 db
	@	16.0 Mhz	8.2 db
	@	25.0 Mhz	10.4 db
	@	100.0 Mhz	22.0 db
Characteristic Impedance	@	1.0 Mhz	100.0 ± 15 ohm
	@	25.0 Mhz	100.0 ± 15 ohm
Worst Pair Near-End Crosstalk (db/100 m)	@	1.0 Mhz	65.3 db
	@	4.0 Mhz	56.3 db
	@	10.0 Mhz	50.3 db
	@	16.0 Mhz	47.3 db
	@	25.0 MHz	44.3 db
	@	100.0 MHz	35.3 db

E. The Category 6 UTP cables shall be installed using a star topology format from the rack in the telecommunications closet to every individual information outlet. Use the jacket color white for telephone cables (marked for T in the attached cable schedule) and jacket color blue for data cables (marked for D in the attached cable schedule).

F. Fiber Optic (FO) cable shall be multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. The outside diameter of the glass-cladded fiber shall be nominally 125 microns, and shall be concentric with the fiber core. Optical fibers shall meet EIA 455-46A and EIA 455-58A. The fiber shall have transmission windows centered at 850 and 1330 nanometer wavelengths. The numerical aperture for each fiber shall be a minimum of 0.275. The attenuation at 850 nanometers shall be 2.9dB/km or less. The attenuation at 1300 nanometers shall be 0.7dB/km or less. The minimum bandwidth shall be 220 MHz-km at 850 nanometers and 1000 MHz-km at 1800 nanometers. FO cable shall be premise riser-rated, NEC riser (OFNR safety standards and must be rated for –20 to 70 deg. C for operating temperature. The cable shall be rated for a maximum short term tensile load is 300 lbs and long term tensile load is 90 lbs.

G. Fiber Optic cable shall be terminated using epoxy heat-cured connector methods. The connector shall be duplex LC type.

H. Patch Panels: Patch panels shall meet or exceed ANSI/TIA/EIA-568-B.2 Category 6 component standards. Each panel shall have 48 each RJ-45 jacks and be one (1.75 inches) or two (3.5 inches) rack units (RU) in height. The patch panels may incorporate individually replaceable jacks. If the jacks are replaceable they should match the color of the outlet jack (white for phone, blue for data). The patch panel labeling system shall be laser-printable and replaceable. The patch panels shall be labeled with the jack number as indicated on the cable plan, and grouped by room number per the cable plan. The contractor shall provide a submittal for patch panels for approval by the resident engineer.

I. The network equipment rack shall be an open frame two or four post construction and accommodate universal panel mounting on the front and back. The rack shall incorporate horizontal and vertical cable management. The rack shall have a minimum of 44 rack units and shall accommodate 19 inch rack equipment mounting. The rack shall have a minimum of 10 inches of clearance between the front and back mounting surfaces. The rack shall be installed with the front facing the door of the Telco room and the rear facing the back wall to facilitate working from both sides of the rack. The rack shall be bolted to the floor in a minimum of two locations using bolts (minimum diameter 3/8”) and anchors installed into the concrete floor. The contractor shall provide a drawing of the rack elevation with patch panels, cable management and open spaces as a submittal to be approved by the resident engineer. The contractor shall coordinate the rack location with the resident engineer to ensure adequate clearances of other electrical and telecommunication equipment in the room prior to installation.

J. Additional cable management panels or devices shall be provided as shown on the equipment rack drawing. Horizontal and vertical cable management shall be provided to manage patch cables in the equipment rack. Suggested device part numbers are Leviton 49253-LPM, 49252-P01, and 49252-P02 or equivalent. Submittals for these devices shall be approved by the resident engineer prior to installation.

K. The length of each individual run of horizontal copper cable from the administration subsystem (Telecommunications Room) to the information outlet/building control device shall not exceed 295 feet.

L. Contractor shall observe the bending radius (four (4) times the cable diameter) and pulling tension (25 pound maximum) requirements of the 4-pair UTP cable during handling and installation.

M. Each cable installed between the patch panel jack and the information outlet/building control device shall be continuous without any splices.

N. Cabling from the wall plate to the cable tray will be routed in ¾" conduit installed from the device to the cable tray. Plastic bushings will be installed on each end of the conduit to protect cables from nicks or damage. In suspended ceiling areas where cable trays or conduit are not available, the Contractor shall bundle station wiring with velcro cable ties at 3 feet distances. The cable bundling shall be supported via flat bottom "J" hooks attached to the building structure and framework.

O. Every effort will be made to schedule the requirements under this Contract in such a manner so as to complete all above ceiling work prior to ceiling tile installation. In the event Contractor is required to remove ceiling tiles, such Work shall not break or disturb grid and must be coordinated with the General Contractor.

P. All cable ties used on this project shall be Velcro-type ties. Nylon cable ties shall not be used on any Category 6 or fiber optic cables.

Q. Continuous conduit runs installed by the contractor should not exceed 100 ft. or contain more than two (2) 90 degree bends without utilizing appropriately sized pull boxes.

R. Information Outlets - All information outlets shall be RJ45 Category 6 modular type. Outlets shall support multiple vendors universal phone and data jacks.

1. Contractor shall provide a duplex data faceplate. Faceplate color shall be as following:

   Faceplates for wall mounted outlet: White

2. Outlets shall be wired in an EIA/TIA 568B configuration. The colors of the outlets shall be as following:

   Voice: White
   Data: Blue
   Blank Snap Fitting: White

3. The faceplates shall accommodate 4-port and 6-port jacks and be constructed of high impact thermoplastic that meets UL 94V-0. (Leviton 42080-4WS and -6WS or equivalent).

4. Wall plates used for a single wall-mounted phone shall be stainless steel, provide integral hardware to support the phone and utilize a single outlet. (Leviton 4108W-OSP or equivalent).

R. Administration Subsystem - The Administration Subsystem links all of the subsystems together. It consists of labeling hardware for providing circuit identification and patch cables used for creating circuit connections at the patch panels. The administration subsystem shall consist of wiring blocks and patch panels for termination of copper cables or light guide interconnection units (LIU) for the termination of optical fibers. All wall/frame layouts shall be approved prior to installation.

S. Station Device/Patch Cables

1. Contractor shall provide cross-connect patch cables for cross-connection between patch panels installed in the equipment rack and station cables for connection from wall plates to network devices. Quantities shall be as follows:
   a) 100 each white patch cables, length 3 feet
   b) 100 each white patch cables, length 5 feet
   c) 100 each white patch cables, length 6 feet
   d) 150 each blue patch cables, length 3 feet
   e) 150 each blue patch cables, length 5 feet
   f) 100 each blue patch cables, length 7 feet
   g) 100 each blue station cables, 14 feet in length
   h) 100 each blue station cables, 25 feet in length

2. All patch cables shall be factory fabricated and meet EIA/TIA Category 6 standards, and incorporate rubber hoods over the connectors as part of the cable.

3.. The Category 6 patch cables shall incorporate the "cross-over lead" concept which employs crosstalk cancellation techniques to provide superior Near-end Crosstalk (NEXT) performance.

4. The Category 6 patch cables shall have built-in exclusion features to prevent accidental polarity reversals and split pairs.

5. All Category 6 patch cables shall be round, 24 gauge tinned copper, stranded conductors insulated with high density polyethylene, tightly twisted into individual pairs and jacketed with flame retardant PVC. The patch Cables shall meet or exceed the following electrical specifications listed below:

   Maximum DC resistance: 0.085 ohm/m

Mutual Capacitance:		52.5pF/m	
Attenuation (dB/100 m)	@	1.0 Mhz	2.30 db
	@	4.0 Mhz	4.72 db
	@	10.0 Mhz	7.28 db
	@	16.0 Mhz	9.18 db
	@	25.0 Mhz	11.68 db
	@	100.0 Mhz	24.40 db
Characteristic Impedance	@	1.0 Mhz	100.0 ± 15 ohm
	@	25.0 Mhz	100.0 ± 15 ohm
Worst Pair Near-End Crosstalk (db/305 m)	@	1.0 Mhz	68.00 db
	@	4.0 Mhz	59.00 db
	@	10.0 Mhz	53.00 db
	@	16.0 Mhz	50.00 db
	@	25.0 MHz	47.00 db
	@	100.0 MHz	38.00 db

6. Data patch cables shall have a blue exterior insulation color. Telephone patch cables shall have a white exterior insulation color. The contractor shall provide each color in the quantities note in 2.2.S.1 above.

7. Fiber Optic Patch Cables: Provide six (6) each duplex LC to LC style, 62.5/125 mm multimode fiber patch cables. Patch cables shall be orange in color.

8. Cable Tray:

The cable tray system shall utilize 4 inch x 18 inch wire mesh type cable tray. The system shall be installed above the suspended ceiling on the second floor and in the attic level, Automation Wing.

System: The wire mesh cable tray system shall be fabricated using high quality welded steel wire. The system permits is flexible to almost any configuration and enabling to handle 90 degree turn. It is easily twist around obstructions and make multiple level changes.

Manufacturer: Thirty calendar days prior to order, submit installation drawings indicating materials, finish, dimensions, and accessories. The drawings shall include the layout, support, connection and cable tray installation details and manufacturer's product data UL classification to the Contracting officer for approval. Contractor shall coordinate drawings with all other disciplines that could conflict with the installation. The shop drawings shall be approved by the FAA prior to the installation of the cable tray.

Grounding: Provide grounding of cable trays by means of low-resistance conductor(s) back to building steel or facility Multipoint Ground System, but in no case smaller than

No. 1/0 AWG copper. These grounding conductors shall be colored green with an orange tracer. The contractor shall bond the grounding conductors to the tray system at a minimum of two locations and not less than every 50 linrear feet. Cable-tray sections can be bonded using compatible bolted connections, and shall be considered as having electrical continuity when these sections are bonded with appropriate hardware by the tray manufacturer. Provide grounding and bonding of cable trays in accordance with NFPA 70, and FAA Standard 019e.

9. Combination Data/Power Outlet: Refer to detail drawing for information.

10. Fiber Optic Innerduct:

All innerduct shall be plenum-rated for this project. The plenum innerduct shall meet UL 910 standards for the National Electrical Code, Article 770, and satisfy UL-2024 standards for low smoke and flame propagation. The plenum innerduct is offered in 1” and 1 1/4” with pre-installed pull tape for easy cable installation. The standard color is orange for fiber optic communications.

PART 3 - EXECUTION

3.1 GENERAL

A. Contractor shall install cables at the network rack and work station jacks in accordance with industry standards.

B. Cables shall be terminated at the MDF, the network rack and jack in accordance with the drawings. Each jack shall be connected to a single cable using EIA/TIA T568B pin/pair assignments. No more than ½ inch of cable sheath shall be removed at jack termination.

C. Color coding shall conform to requirements of EIA/TIA Standards.

D. Connections between the PBX riser termination blocks and the PBX patch panels shall be made by the FAA.

3.2 LABELING

A. Components of the cabling system shall be labeled in accordance with the drawings.

B. Each jack shall be labeled with its jack number clearly marked on the face plate and on the patch panel. Each jack shall be labeled as shown on the drawings.

C. Cables shall be clearly marked within 6" of each end with cable numbers from the schedules.

D. Label cable trays at each end and at every twenty feet along its length.

E. Label terminating hardware (blocks, patch panels, and similar appurtenances) in accordance with the drawings.

3.3 TESTING

A. Contractor shall test the installed system from the patch panels to the station jacks for opens, shorts, grounds, crossed pairs, cross talk and impedance to ensure integrity of the cable plant.

B. Test plan, equipment and methods user and an example of results shall be provided to FAA resident engineer for approval prior to start of testing.

B. Performance criteria for UTP shall be in accordance with EIA/TIA 568-B other performance criteria defined for Category 6 performance. (Following specification list before in 2.2.B)

C. Test criteria for the installed telecommunications cable plant are shown in the following table. Testing shall be a Category 6 channel performance test and measurements shall be made from the wall jack to the patch panel connection in accordance with EIA/TIA TSB-62 and EIA/TIA 568-B Annex E.

D. Conduct tests with a telecommunications cable tester (Fluke DTX – 1800 or equivalent) and Optical Time Domain Reflectometer (OTDR) which provides a database of the test results for each circuit. The contractor shall provide hard and soft copy of test results, and shall replace any cable or component that does not meet Category 6 criteria.

Table 17200-1 Cable Plant Test Criteria

PARAMETER	FREQUENCY (MHz)	PERFORMANCE LIMIT (Db)
MAX. CHANNEL ATTENUATION	1.0	2.5
	4.0	4.5
	8.0	6.29
	10.0	7.0
	16.0	9.2
	20.0	10.3
	25.0	11.4
	31.25	12.8
	62.5	18.5
	100.0	24.0
NEXT (meas. From Telecommunications Outlet (TCO))	1.0	60.3
	4.0	50.6
	8.0	45.6
	10.0	44.
	16.0	40.6
	20.0	39.0
	25.0	37.4
	31.25	35.7
	2.5	30.6
	100.0	27.1
NEXT (meas. from Telecommunications Closet (TCC))	1.0	54.5
	4.0	49.5
	8.0	45.5
	10.0	44
	16.0	40.5
	20.0	38.5
	25.0	37.0
	31.25	35.5
	62.5	30.5
	100.0	27.0

3.4 CLEANING

A. Upon completion of work, remove excess debris, materials, equipment, apparatus, tools and similar items, and leave the premises clean, neat and orderly.

END OF SECTION 16740

SECTION 16770

PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the material and work required to install a new paging system in the Automation Wing Second Floor and Attic. This system is an upgrade and expansion of the existing paging system located in the Automation Wing Basement.

B. The system shall consist of a new audio distribution network consisting of speakers, cabling raceway, and any ancillary components required to meet the system configuration as shown on the Drawings and specified herein.

C. The access to the public address system shall be in the same manner as is currently used. The speaker locations are shown on the Drawings. The existing power amplifier equipment shall, as a minimum be capable of driving all speaker circuits at a 0.5 watt average power level. Replace the amplifier if required.

1.2 REFERENCE STANDARDS

Applicable only to the extent specified.

A. Electronic Industries Association (EIA)

1. 160-51 Standard for Sound Systems
2. SE-101-A-49 Standard for Amplifiers for Sound Equipment
3. SE-103-49 Standard for Speakers for Sound Equipment

B. Federal Aviation Administration (FAA)

1. C-1217f Electrical Work, Interior
2. Std-019b Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities

C. National Fire Protection Association (NFPA)

1. 70 National Electrical Code (NEC)

D. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

E. Underwriters Laboratories (UL)

1. 50 Enclosures for Electrical Equipment

1.3 SUBMITTALS

A. Complete list of equipment and materials.

B. Product data for each type of equipment supplied, including: manufacturer's descriptive and technical literature; performance charts and curves; catalog cuts; and installation instructions.

C. Complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Identify terminals to facilitate installation, operation, and maintenance. Manufacturer-installed and field-installed wiring will be different.

D. Installer certificates signed by manufacturer certifying that Installers comply with requirements specified under the "Quality Assurance" Article. Upon request, submit evidence of experience and of relationship with system manufacturer.

E. Manufacturer certificates signed by manufacturer certifying that manufacturers comply with requirements specified under the "Quality Assurance" Article. Upon request, submit evidence of manufacturing experience.

F. Report of field tests and observations, including record of final tap settings of speaker line matching transformers and signal ground-resistance measurement certified by Installer.

G Maintenance data for system to include in the operation and maintenance manual specified in Section 16050, "Basic Electrical Materials and Methods."

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who is an authorized representative of the system manufacturer to perform Work of this Section.

B. Manufacturer Qualifications: Engage a firm experienced in manufacturing public address systems complying with the requirements of these Specifications and experienced with at least 5 projects of similar size and scope that have been in operation for 3 years or more.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A NRTL as defined in OSHA Regulation 1910.7.

D. Comply with NFPA 70.

E. Comply with UL 50.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section shall be in accordance with FAA C-1217f and FAA Std-019b.

B. Materials and equipment provided shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. All components used in the system shall be commercial designs that comply with the requirements specified.

2.2 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that are compatible with the existing public address amplifier manufactured by Bogen Communications, Inc. The existing amplifier is a Bogen model C60C.

2.3 SYSTEM REQUIREMENTS

A. Coordinate the features of the new speakers with the existing equipment to form an integrated system. Match components and interconnections for optimum performance of specified functions.

B. Functional Performance: The system shall provide even sound distribution throughout the designated areas, plus or minus 3 dB for the 1 octave band centered at 4,000 Hz. The system shall provide uniform frequency response through out the designated areas, plus or minus 3 dB, as measured with 1/3 octave bands of pink noise at locations across the designated area selected by the COR. The system shall be capable of delivering 70 dB average voice level with additional 10 dB peaking margin sound pressure level (SPL) to any location in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless other wise specified, the sound pressure reverence level is 20 micro Pascal (0.00002 Newton per square meter).

C. Telephone Paging: The system shall continue to have the ability to page by dialing an extension from any local telephone instrument and speaking into the telephone. The system returns to original operating mode when telephone is hung up.

D. High-Quality Sound Reproduction: Sound is free from noises, such as pops, clicks, hisses, and hums at all loudspeakers at all times during system operation, including standby mode between paging activities. System output is free from distortion and non-uniform coverage of amplified sound.

2.4 EQUIPMENT

A. General: Use all solid-state components, fully rated for continuous duty at the ratings indicated.

B. Cone-Type Loudspeakers: Comply with EIA-SE-103. Provide units with the following minimum features:

1. Axial Sensitivity: 45 dB minimum per EIA standard.
2. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
3. Size: 8 inches (203 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (142-g) ceramic magnet, except as otherwise indicated.
4. Dispersion Angle: 100 degrees.
5. Rated Output Level: 1.0 W.
6. Matching Transformer: Comply with EIA-160. Full-power rated with 4 EIA standard taps. Maximum insertion loss is 0.5 dB.

7. Flush-Ceiling Mounting Units: In steel back boxes, acoustically dampened, with provision for relief of back pressure. Metal ceiling grille is with baked, white-enamel finish. Provide unit with heavy duty wire-wound volume control with knob. Use Bogen ceiling speaker model CS1EZ or equivalent
8. Wall Mounting Units: Surface mounted in steel boxes, acoustically dampened, with provision for relief of back pressure. Front face of at least 0.0478 inch (1.2 mm) steel, and the whole assembly rust proofed and shop primed for field painting. Provide unit with recessed volume control. Use Bogen wall baffle speaker WB1EZ or equivalent.

C. Volume Attenuation Stations: Wall plate-mounted auto transformer type.

1. Wattage Rating: 10 Watt, unless otherwise indicated.

2. Attenuation per Step: 3 dB, with positive OFF position.

3. Insertion Loss: 0.4 dB maximum.

4. Label: “PA Volume”

D. Wire and Cable: Cables shall be of the gauge required depending upon the cable run length. In no case shall any cable be used that is less than 18 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less that 1/32 inch thick. Cables shall be twisted-pair, untinned, solid copper conductors, jacketed with a PVC compound. Jacket thickness shall be 0.0200 inch minimum.

PART 3 - EXECUTION

3.1INSTALLATION

A. General: Install equipment to comply with manufacturer's written instructions and in accordance with FAA C-1217f and FAA Std-019b.

B. Wiring Method: Install wiring in raceway. Raceway shall extend from the second floor to the location of the amplifier in the Automation Wing Basement.

C. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures.

D. Impedance and Level Matching: Carefully match input and output impedance and signal levels at audio signal interfaces. Provide matching networks where required.

E. Provide physical isolation between speaker and power wiring. Run in separate raceways or provide 12-inch minimum separation where exposed or in same enclosure. Provide additional physical separation as recommended by equipment manufacturer.

F. Identification of Conductors and Cables: Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.

3.2GROUNDING

A. Ground cable equipment to eliminate shock hazard and to minimize ground loops, common mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at existing amplifier. Connect signal ground to main building ground system.

3.3FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the testing and adjustment of the system.

B. Testing Procedure: Conform to the following:

1. Test Plan: Submit a test plan to the COR for approval at least 30 days prior to conducting the acceptance tests. The test plan shall describe the test procedures, explaining in detail, step by step actions and expected results to demonstrate compliance with the requirements specified. The plan shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance.
2. Schedule tests with the COR, a minimum of 7 days in advance of performance.
3. Acceptance Test: Conduct acceptance tests utilizing the approved test procedures to demonstrate that the equipment operates in accordance with specification requirements. The tests shall include originating and receiving messages at specified stations, at proper volume levels, without cross talk or noise from other links or non-designated units.
4. Report: Submit a written record of test results.

C. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

D. Retesting: Rectify deficiencies indicated by tests and observations. Include revising tap settings of speaker line matching transformers where necessary to optimize volume and uniformity of sound levels. Completely retest work affected by such deficiencies at the Contractor's expense. Verify by the system tests that the total system meets the Specifications and complies with applicable standards. Provide a written record of all retest results.

3.4CLEANING

A. Prior to final acceptance, clean system components and protect from damage and deterioration.

3.5DEMONSTRATION

A. Demonstration and Training: Provide the services of a qualified instructor to demonstrate the system in all operating modes and functions, and to train Government maintenance personnel.

B. Schedule training with Owner with at least 7 days' advance notice.

C. Train Government maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance. Provide a minimum of 3 hours' training.

D. Training Aid: Use the approved operation and maintenance manual as an instructional aid. Refer to Section 16050, "Basic Electrical Materials and Methods." Provide copies of pertinent excerpts from the manual for use in the instruction.

3.6ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, resetting matching transformer taps, adjusting controls, and investigating possible need for any system revisions required to meet actual occupancy conditions. Provide up to 1 visit to the site for this purpose.

END OF SECTION 16770

FAA-C-1217f
February 26, 1996
SUPERSEDING
FAA-C-1217e,

US DEPARTMENT
01/25/91
OF TRANSPORTATION
Federal Aviation
Administration

U. S. Department of Transportation
Federal Aviation Administration
Specification

ELECTRICAL WORK, INTERIOR

FORWARD

This document has been revised to reflect current technology changes and to incorporate the latest commercial standards.

1. SCOPE

1.1 Scope.- This specification covers the ***minimum requirements*** for electrical work at FAA facilities. Where the phrase "unless otherwise indicated" or similar wording appears, it refers exclusively to other documents that are specific parts of the contract. Where there are requirements peculiar to specific FAA facility types, e.g., air route traffic control centers (ARTCCs), metroplex control facilities (MCFs), terminal radar control (TRACONs), etc., these requirements will be added following the appropriate paragraph.

2. APPLICABLE DOCUMENTS.- The current issues of the following documents in effect on the date of the invitation-for-bids or request-for-proposals form a part of this specification, and are applicable to the extent specified herein.

2.1 Federal specifications

J-C-30	Cable and Wire, Electrical (Power, Fixed Installation)
W-C-375	Circuit Breakers, Molded Case; Branch Circuit and Service
W-F-414	Fixture, Lighting (Fluorescent, Alternating Current, Pedant Mounting)
W-L-305	Light Set, General Illumination (Emergency or Auxiliary)
W-P-115	Panel, Power Distribution
WW-C-566	Conduit, Metal, Flexible
QQ-W-343	Wire, Electrical, (uninsulated)

(To obtain copies of federal specifications, contact General Services Administration offices in Washington DC, Atlanta, Boston, Chicago, Dallas, Denver, Kansas City MO, Los Angeles, New York, San Francisco, or Seattle.)

2.2 Steel Structures Painting Council standards

SSPC-PS 10.01 Hot-Applied Coal Tar Enamel Painting System

(Single copies of SSPC Standards can be obtained from the Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, Pa 15213, 412/578-3327)

2.3 Federal Aviation Administration specification/standards/orders

FAA specification:

FAA-C-1391 Installation and Splicing of Underground Cables

FAA standards:

FAA-STD-019 Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities

FAA-STD-020 Transient Protection, Grounding, Bonding and Shielding Requirements for Electronic Equipment

FAA orders:

3900.49 Control of Hazardous Energy During Maintenance, Servicing and Repair

6950.19 Practices and Procedures for Lightning Protection, Grounding, Bonding and Shielding Implementation

6950.20 Fundamental Consideration of Lightning, Protection, Grounding, Bonding and Shielding

6950.22 Maintenance of Electrical Power and Control Cables

6950.27 Short Circuit Analysis and Protective Device Coordination Study

(Copies of FAA specifications may be obtained from the Contracting Officer in the office issuing the invitation-for-bids or request-for-proposals. Requests should fully identify material desired, i.e., specifications, standard, amendment, and drawing numbers and dates. Requests should cite the invitation-for-bids, request-for-proposals, or the contract involved or other use to be made of the requested material.)

2.4 National Fire Protection Association (NFPA) publications

NFPA 70 National Electrical Code (NEC)

(Requests for copies of NFPA publications should be addressed to the National Fire Protection Association, Batterymarch Park, Quincy MA 02269.)

2.5 National Electrical Manufacturers Association (NEMA) standards

OS-1 Sheet Steel Outlet Boxes, Device Boxes, covers and Box Supports

MG-1 Standard for Motors and Generators

ST 20 Dry Type Transformers for General Applications

VE 1 Cable Tray Systems

WC 5 Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

WD 1 General Requirements for Wiring Devices

(For copies of NEMA standards, contact the National Electrical Manufacturers Association, 2101 L Street N.W. Washington DC 20057, 202/457-8400.)

2.6 Underwriters' Laboratories (UL) Inc. standards

UL 5 Surface Metal Raceways and Fittings

UL 6 Rigid Metal Conduit

UL 50 Enclosures for Electrical Equipment

UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors

UL 486C Splicing Wire Connectors

UL 486E Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

UL 514A Metallic Outlet Boxes

UL 514B Fittings for Conduit and Outlet Boxes

UL 542 Lampholders, Starters, and Starter Holders for Fluorescent Lamps

UL 651 Schedule 40 and 80 Rigid PVC

UL 797 Electrical Metallic Tubing

UL 870 Wireways, Auxiliary Gutters and Associated Fittings

UL 935 Fluorescent-Lamp Ballasts

UL 1242 Intermediate Metal Conduit

(For copies of UL standards, contact Underwriters' Laboratories Inc., Publication Department, 333 Pfingsten Rd., Northbrook IL 60062.)

2.7 Institute of Electrical and Electronics Engineers (IEEE) Inc. standards

STD C57.12.80 Standard Terminology for Power and Distribution Transformers

STD 141 Recommended Practice for Electric Power Distribution for Industrial Plants

STD 519 Recommended Practices and Requirements for Harmonic Control and Electrical Power Systems

STD 1100 Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

For copies of this standard, contact the IEEE Inc., Service Department, 445 Hoes Lane, PO Box 1331, Piscataway NJ 08855-1331.)

2.8 Other documents

2.8.1 Local utility companies.- The rules and regulations of the local utility companies providing service.

2.8.2 Local governing bodies.- The rules, regulations, and codes of local governing bodies.

3. MATERIALS

3.1 General.- The contractor shall furnish all materials not specifically identified as Government Furnished Materials in the invitation-for-bids or contract. Materials and equipment shall comply with all requirements of the contract documents. Materials furnished by the contractor shall be new, the standard

products of manufacturers regularly engaged in the production of such materials, and of the manufacturer's latest designs that comply with the specification requirements. If materials and equipment requirements conflict, the order of precedence for selection shall be as follows: special contract provision, the contract drawings, this specification, and then continuing order of precedence, referenced FAA documents, Military documents, Federal specifications, NFPA publications, IEEE standards; UL standards and NEMA standards. Wherever standards have been established by Underwriters' Laboratories, Inc., the material shall bear the UL label.

4. INSTALLATION

NOTE: Unscheduled interruptions of the electrical service to FAA facilities may cause aircraft accidents and loss of life. Work requiring a temporary or permanent deenergization of equipment shall be scheduled in writing with the onsite FAA maintenance personnel. Only onsite FAA maintenance personnel are authorized to energize, deenergize equipment or to operate a circuit breaker, switch, or fuse in an FAA facility. Work procedures shall include lock-out/tag-out procedures in accordance with FAA Order 3900.49.

4.1 General.- The rules, regulations and reference specifications enumerated herein shall be considered as minimum requirements. FAA requirements often exceed those of other standards organizations such as the NEC. Adherence to other standards shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by this specification. Adherence to this specification shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by the contract drawings or special contract provisions. This specification shall govern when conflicts occur between it and the documents referenced in paragraph 2, Applicable documents, and in the order of precedence established in paragraph 3, Materials.

4.1.1 Short circuit analysis and protective device coordination (SCA/PDC). - The distribution system and all component parts, when installed or as modified, shall be in accordance with IEEE Standard 519, Recommended Practices and Requirements for Harmonic Control and

Electrical Systems, and shall include a short circuit analysis and protective device coordination study in accordance with FAA Order 6950.27.

4.2 Workmanship.- All materials and equipment shall be installed in accordance with the contract drawings. When manufacturers recommended installation methods conflict with contract requirements, differences shall be resolved by the Contracting Officer. The installation shall be accomplished by qualified workers regularly engaged in this type of work. Where required by local regulations, the workers shall be properly licensed.

4.3 Contract drawings.- Where the electrical drawings indicate (by diagram or otherwise) the work intended and the functions to be performed, even though some details are not shown, the contractor shall furnish all equipment, material (other than the Government-furnished items, see paragraph 3.1) and labor to complete the installation work and to accomplish all the indicated functions of the electrical installation. Further, the contractor shall be responsible for taking the necessary actions to ensure that all electrical work is coordinated and compatible with architectural, mechanical, and structural plans, and the layout of any special electronic equipment.

4.3.1 Minor departures.- Minor departures from exact dimensions shown on the electrical plans may be permitted when required to avoid conflict or unnecessary difficulty in placement of a dimensioned item, provided all contract requirements are met. The contractor shall promptly obtain approval from the Contracting Officer prior to undertaking any such departure and shall provide appropriate documentation of the departure.

4.4 Grounding

4.4.1 General.- FAA grounding requirements often exceed those of the NEC. Grounding systems shall be as indicated on the contract drawings and as specified herein. Reference IEEE Standard 1100-1992, Recommended Practice for Powering and Grounding Sensitive Electronic Equipment, when installing all NAS equipment. In no case, however, shall the NEC be violated.

4.4.2 Grounding electrode conductor.- The grounding electrode conduct shall be bare or insulated copper and shall be sized as shown in the contract documents. When not indicated in the contract documents, the conductor shall be copper and sized in accordance with Table 250-94, "Grounding Electrode Conductor for AC Systems", of the NEC, except that the conductor shall not be smaller than No. 6 AWG. Where the grounding electrode conductor is routed through a metal raceway, the raceway shall be electrically continuous and bonded to the conductor at each end. The grounding electrode conductor shall be bonded to the earth electrode system with an exothermic welded joint. For a separately derived system such as an isolation transformer, the grounding electrode conductor shall be connected in accordance with the NEC. This conductor shall be permitted to terminate by exothermic welding to an equipment room's perimeter ground cable under a raised floor.

4.4.3 – Earth electrode system.- The earth electrode system shall be installed as shown in the contract documents. Unless otherwise indicated in these documents, the earth electrode system shall consist of a minimum of four (4) ground rods located at the corners of a structure. Rods shall be spaced apart a distance equal to or greater than the length of the rods. Ground rods shall be 3/4 inch by 10 feet, copper or copper-clad steel. Sectionalized type or exothermic butt welded rods shall be used when deeper earth penetration is required. Rods shall be interconnected by a bare copper cable forming a closed loop around a structure. The cable shall be a minimum No. 4/0 AWG and shall be buried at least 2 feet below grade. The top of the vertically-driven ground rods shall be a minimum of 12 inches below grade. All underground metal pipes (excluding gas piping systems), tanks, and the telephone ground, if present, shall be connected to the earth electrode system by a copper cable no smaller than No. 2 AWG. All underground connections shall be made by exothermic welding process unless otherwise indicated.

4.4.4 Earth electrode system resistance.- The resistance of the earth electrode system shall not exceed 10 ohms, as tested per paragraph 5.3.6, unless otherwise indicated. If the measured resistance exceeds 10 ohms,

the Contracting Officer shall be notified immediately for further guidance.

4.4.5 Equipment grounding conductor

4.4.5.1 General.- All metallic non-current carrying parts of electrical equipment shall be grounded with equipment grounding conductors whether or not shown on the drawings. Equipment grounding conductors shall always be green insulated copper conductors unless otherwise indicated. Non-insulated equipment grounding conductors are not allowed. When these conductors are not sized, or shown on the contract drawings, they shall be sized in accordance with Table 250-95, "Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment", of the NEC.

4.4.5.2 Connections.- There shall be no interconnection between equipment grounding conductors and neutral conductors except at the main service and separately derived sources. All connections to equipment to be grounded shall be made with a grounding connector specifically intended for that purpose. Bare wire, wrapped around mounting bolts and screws, is not acceptable as a grounding connection. All ground lugs shall be of a noncorrosive material suitable for use as a grounding connection, and must be compatible with the type of metal being grounded. All mating surfaces and connections shall be between cleaned bare metal to bare metal surfaces.

4.4.5.3 Installation.- Each overcurrent device shall have its own equipment grounding conductor, i.e., a single-pole single-phase overcurrent device shall be supplied with an equipment grounding conductor; a two-pole, single-phase overcurrent device shall be supplied with its own equipment grounding conductor; a three-pole, three-phase overcurrent device shall be supplied with its own equipment grounding conductor. The equipment grounding conductor shall be installed in the same conduit as its related branch and feeder conductors and shall be connected to the ground bus in the branch or distribution panelboard. Metal conduit housing the equipment grounding conductor shall be electrically continuous, forming a parallel path to the equipment grounding conductor, except as allowed by the NEC. Where parallel feeders are installed in more than one raceway,

a full sized equipment grounding conductor shall be installed in each raceway.

4.4.6 Raceway grounding.- Surface metal raceways, wireways, or cable rack systems shall be installed in a manner that assures electrical continuity. Insulated copper bonding jumpers shall be installed between adjacent raceway sections to assure proper bonding. Uninsulated conductors shall not be used. Unless otherwise indicated, the minimum size for these bonding jumpers shall be No. 6 AWG. Where aluminum raceways are used, the jumpers shall be bonded with approved connectors for the dissimilar metals. All metallic raceway penetrations into a facility structure shall be bonded to the earth electrode system in accordance with FAA-STD-019.

4.4.7 Other grounding systems.- Any additional grounding systems used for electronic equipment shall be connected directly to the exterior earth electrode system or the perimeter ground cable under a raised floor in an equipment room. Other grounding systems shall not be used in place of the equipment grounding conductor system. The conductor used for other grounding (i.e., NEC 250-74, exception #4) systems shall be color coded green with a yellow stripe for single point isolated signal ground, green with an orange stripe for multipoint signal ground, green with a red stripe for high energy ground, green with a violet stripe for isolated equipment grounding connections.

4.5 Electrical surge protection

4.5.1 General.- All electrical surge protection systems shall be installed in accordance with FAA-STD-019.

4.5.2 Supply transformer.- For utility owned transformers, protective devices shall be at the discretion of the utility. For FAA—owned transformers, proper protection shall be provided on the primary side of the transformer.

4.5.3 Service entrance surge arrester.- A fused surge arrester provided with disconnect capability shall be installed on the line, (supply-side) of the service as close as possible to the service terminals. Separate terminating lugs shall be provided for the surge

arrester. This arrester shall be compatible with the service voltage, and shall be wired to avoid loops, sharp bends and kinks, and to minimize the number of bends. There shall be no interconnection between neutral and ground within the arrester. Arrester conductors shall be No. 4 AWG insulated copper or larger, unless a smaller size is recommended by the arrester manufacturer.

4.5.4 Transient suppression installations.- Where transient suppression devices are installed in the electrical power distribution system they shall be installed in accordance with manufacturers instructions unless otherwise specified.

4.5.5 Land line/cable penetration installations.- Suppression systems shall be provided for land line and cable penetration systems in accordance with FAA-STD-019. High energy grounding conductors shall be bonded directly to the earth electrode system or to the perimeter ground cable under raised floors in equipment rooms.

4.6 Wiring methods

4.6.1 General.- All wiring shall consist of insulated copper conductors installed in metallic raceways, unless otherwise specified.

4.6.1.1 Conductor routing.- Panelboards, surge arresters, disconnect switches, etc., shall not be used as raceway for conductor routing other than conductors that originate or terminate in these enclosures. Isolated ground conductors will be allowed to traverse these enclosures.

4.6.1.2 Conductor separation - Power conductors shall be routed separately from all other conductor types. This may be accomplished by routing power conductors and other conductors in separate raceways, or by a metallic divider between the power conductors and the other conductors in the same raceway.

4.6.2 Neutral conductor.- Shared/common neutrals shall not be permitted, i.e., each overcurrent device shall have its' own separate neutral conductor. Neutral conductor sizes shall not be less than the respective feeder or phase conductor sizes.

4.6.3 Raceway systems

4.6.3.1 General.- Each run shall be complete, and shall be fished and swabbed before conductors are installed. Ends of raceway systems not terminated in boxes or cabinets shall be capped. Exposed raceways shall be installed parallel to or at right angles with the lines of the structure. Crushed or deformed raceways shall not be installed. A pull wire shall be installed in all empty tubing and conduit systems in which wiring is to be installed by others. The pull wire shall be No. 14 AWG zinc-coated steel, or plastic with a minimum 200-pound tensile strength. Ten inches of slack shall be left at each end of the pull wire. Sections of raceways which pass through to damp, concealed, or underground locations shall be of a type allowed for such locations by NEC Article 300-5, and shall extend a minimum of 12 inches beyond the damp, concealed, or underground area. Where raceway has to be cut in the field, it shall be cut square and burrs and sharp edges removed. Where conduits penetrate walls or floors separating the building interior from the exterior, they shall be sealed to prevent moisture and rodent entry and to deter air transfer. In addition, where conduits penetrate walls separating individually controlled temperature or humidity controlled areas, they shall be sealed to prevent air circulation. Sealing methods and sealants shall be accordance with NEC Article 300-7. Openings around penetrations through fire-resistant-rated walls, partitions, floors, or ceilings shall be fire stopped using approved methods to maintain the fire resistance rating.

4.6.3.2 Conduit. — Minimum conduit size shall be 3/4 inch unless otherwise specified. Conduit for telephone and signal systems shall be allowed to be 1/2 inch. Where threads have to be cut on conduit, the threads shall have the same effective length and shall have the same thread dimensions and taper as specified for factory cut threads on conduit.

NOTE:

For ARTCCs, MCFs, and Large TRACONs, rigid steel conduit (RSC)or intermediate metal conduit (IMC) shall be used for all distribution panel feeders, transformer feeders, motor control center feeders and distribution

switchboards. Electrical metallic tubing (EMT) maybe used for communication, lighting and branch circuits.

4.6.3.2.1 Zinc coated rigid steel conduit (RSC).- Zinc coated rigid steel conduit (RSC) shall conform to UL 6. RSC, may be used in all locations and shall be used for all underground service conductors. For installation below slab, on-grade, or underground, the conduit shall conform to Steel Structures Painting Council Standard, SSPC-PS 10.01, or shall be field wrapped with 0.01-inch thick pipe wrapping plastic tape applied with 50% overlap. Fittings used underground shall be protected by field wrapping as specified herein for conduit. All fittings used with rigid steel conduit shall be the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

4.6.3.2.2 Intermediate metal conduit (IMC). IMC shall be zinc coated steel, shall conform to UL Standard 1242, and shall bear the UL label. For installation below slab on grade or underground, the conduit shall conform to Steel Structures Painting Council Standard, SSPC-PS 10.01, or shall be field wrapped with 0.01-inch thick pipe wrapping plastic tape applied with 50% overlay. Fittings used underground shall be protected by field wrapping as specified herein for conduit. Where it is necessary to fabricate IMC bends in the field, the tooling required to fabricate those bends shall be specifically designed for IMC. All fittings shall be of the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

4.6.3.2.3 Electrical metallic tubing (EMT).- EMT shall conform to UL 797. EMT may be used only in dry interior locations, and where not subject to physical damage. EMT shall not be used on circuits above 600 volts nor in sizes greater than 34 inches in diameter. Fittings used

with EMT shall be standard compression-type fittings designed for this type of EMT, unless otherwise indicated. Screw-type fittings are not acceptable. Where EMT enters enclosures without threaded hubs, an appropriate connector with threads and cast or machined (not sheet metal) locknut shall be used to securely bond the conduit to the enclosure. The connector body and locknut shall be installed so that firm contact is made on each side of the enclosure. In addition the connectors shall have an insulated-throat, smooth bell shaped end, or a bushing.

4.6.3.2.4 Rigid aluminum conduit.- Aluminum raceways shall not be used for any installation.

4.6.3.2.5 Rigid nonmetallic conduit.- Rigid nonmetallic conduit shall be heavywall PVC conforming to UL 651. Rigid nonmetallic conduit used to protect electrical power conductors may only be used underground, or in concrete, or as a vertical riser to 6 inches above grade or floor surface for connection to metal conduit; and only when required by the contract drawings or specific job specifications. PVC fittings shall be used with PVC conduit and shall be assembled in accordance with manufacturer's instructions. A PVC threaded fitting with locknut and plastic bushing shall be used to connect PVC conduit to boxes or cabinets without threaded hubs. Rigid nonmetallic conduit may be used to protect lightning protection system conductors and, in interior locations, to protect signal grounding conductors.

4.6.3.2.6 Flexible metal conduit.- Flexible metal conduit shall conform to Federal Specification, WW-C-566. Flexible metal conduit shall be used for terminal connections to motors or motor driven equipment, and in lengths only up to 6 feet for other applications permitted by the NEC. Liquid-tight flexible metal conduit shall be used outdoors and in wet locations. All flexible metal conduit shall be of a type where both the conduit and fittings are listed for grounding. This last requirement shall not apply to factory assembled equipment.

NOTE: Flexible metal conduit may be used under raised floor for branch circuits in lengths longer than 6 feet in computer room locations that meet all the requirements

of Article 645 of the NEC. All fittings and junction boxes shall be liquid tight types under the raised floor.

4.6.3.2.7 Flexible nonmetallic conduit.- Flexible nonmetallic conduit shall not be used.

4.6.3.3 Surface raceways.- Nonmetallic surface raceways shall not be used. Surface metal raceways shall conform to UL 5. Surface metal raceways shall be installed only in exposed, dry locations not subject to physical damage. Surface metal raceways shall meet NEC requirements, however, they shall not be used for circuits above 600 volts.

4 .6.3.4 Wireways.- Wireways shall conform to UL 870. Wireways shall only be installed in accessible locations. Wireways installed in wet or outdoor locations shall be rated for these locations.

4.6.3.5 Cable rack systems

4.6.3.5.1 General.- Cable rack systems shall be of the ladder or ventilated trough type conforming to NEMA Standard VE l, unless otherwise indicated. All components for each cable rack system shall be the product of a single manufacturer. Cable rack support spacing shall be as recommended by the manufacturer except that in no case shall spacing of supports exceed 6 feet. Cable racks shall be supported from structural members only.

4.6.3.5.2 Dimensions.- Straight sections, bends, tees, offsets, reducers, etc., for ladder-type cable rack systems shall consist of 3 inch minimum side channels with suitable cross channels (rungs) installed on 6 inch centers unless otherwise indicated. Straight sections, fittings, etc., for ventilated-type cable rack systems, shall have 3 inch minimum high sides and a ventilated bottom with cross pieces 2 inches (maximum) wide on 3 inch (maximum) centers and openings 2 inches (maximum) wide. Cable rack widths shall be as shown on the drawings.

4.6.4 Raceway support systems

4.6.4.1 General.- Raceways shall be securely supported at intervals specified in the NEC Article 300-11,

"Securing and Supporting", and fastened in place with pipe straps, wall brackets, hangers, or ceiling trapezes. Fastenings shall be by wood screws, nails or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion-bolts on concrete or brick; by machine screws, welded threaded studs, or spring tension clamps on steel work. Nail type nylon anchors or threaded studs driven by a power charge and provided with lock washers and nuts may be used in lieu of expansion bolts, machine screws, or wood screws. Threaded C clamps with retainers may be used. Raceways or pipe straps depth of more than 1-1/2 inch in reinforced concrete beams, or to a depth of more than 3/4 inch in reinforced concrete joists, shall not cut the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported from sheet-metal roof decks. In suspended-ceiling construction, raceways shall not be fastened to the suspended-ceiling supports.

4.6.4.2 Telephone and signal raceways.- Telephone and signal system raceways shall be installed in accordance with the previous requirements for conduit and tubing, with the additional requirements that no length of run shall exceed 50 feet for 1/2-inch and 3/4-inch sizes, and 100 feet for-1-inch or larger sizes; and shall not contain more than two 90-degree bends or the equivalent. Pull or junction boxes shall be installed to comply with these limitations, whether or not indicated on the drawings. Bends in conduit, 1 inch and larger, shall have minimum inside radii of 12 times the nominal conduit diameter.

4.6.5 Conductors

4.6.5.1 Uninsulated conductors.- Uninsulated conductors shall be copper and in accordance with Federal Specification QQ-W-343.

4.6.5.2 Insulated conductors.- Unless otherwise indicated, insulated conductors shall be copper with thermoplastic or thermosetting insulation, type THW, THWN, and XHHW for general use, or type THHN for use in dry locations only, all insulated for 600 volts in accordance with Federal Specification J-C-30. Unless otherwise indicated, conductors No. 10 AWG and smaller shall be solid. Conductors No. 8 AWG and larger shall be

stranded. Minimum branch circuit conductor size shall be No. 12 AWG. Stranded conductors may be used with wire compression connectors or a pressure washer type lug; lugs with screw only compression are not allowed. Minimum control wire size shall be No. 14 AWG unless noted otherwise. Stranded conductors smaller than 10 AWG is allowed in applications where vibration and flexing may be encountered.

4.6.5.2.1 Fixture wiring.- Fixture wiring shall be thermoplastic insulated copper, rated for 600 volts, in accordance with Federal Specification J-C-30 and the NEC.

4.6.5.2.2. Color coding.- All feeder and branch circuits, including neutral conductors, shall be identified at both ends of the conductor with panel and circuit number indicated. This shall be accomplished using shrink embossed labels only. The color coding shall be continuous throughout the facility on each phase conductor to its point of utilization so that the conductor phase connection is readily identifiable. Equipment grounding conductors shall be color coded green. Conductors covered with green insulation with yellow, orange, violet or red tracers shall be used for other grounding systems. Neutral conductors shall be white insulated for 120/208/240 volt systems and gray insulated for 277/480 volt systems. For conductors, No. 4 AWG and larger, where appropriate insulation color is not available, color coded tape, half lapped for a minimum length of 3 inches shall be used. Switch leg conductors shall be violet insulated. Green, white, and gray insulated conductors shall not be reidentified. All conductor color codes including reidentified conductors shall be visible at all junction boxes, pullboxes, panelboards, outlets, switches, at access locations in closed raceways, every three (3) feet in open raceways, under all raised floors and at all terminations. Phase conductors shall be color coded as follows:

Single Phase

120 Volts	120/208/240 Volts
Line 1 - Black	Line 1 - Black
	Line 2 - Red
Neutral - White	Neutral - White

Three Phase

120/208/240 Volts	277/480 Volts
Phase A - Black	Phase A - Yellow
Phase B - Red	Phase B - Brown
Phase C - Blue	Phase C - Orange
Neutral - White	Neutral - Gray

Color coding for conductors in control cables shall be in accordance with NEMA Standard WC 5. DC power conductors. shall be color coded as follows: positive conductor, red with brown tracer; negative conductor, brown with red tracer; neutral conductors, if used, shall be white.

4.6.5.3 Splices.- Splices shall be made only at outlets , junction boxes or accessible raceways. Splicing of ungrounded conductors in panelboards is not permitted. Splices shall be made with solderless connectors conforming to UL 486A, UL 486C, AND UL 486E. Insulated wire nuts may only be used to splice conductors sized No. 10 AWG and smaller. Compression connectors shall be used to splice conductors No. 8 AWG and larger. All splices, including those made with insulated wire nuts, shall be insulated with electrical tape or shrink tubing to a level equal to that of the factory insulated conductors. All underground splicing shall be accomplished in accordance with FAA-C-1391.

NOTE:

Conductors in critical power systems shall not be spliced.

4.7 Boxes.- Boxes shall be either the cast-metal threaded-hub type conforming to UL 514A and UL514B, galvanized steel type conforming to UL 514A and UL 514B, or metal outlet boxes conforming to NEMA OS l. All enclosures shall conform to NEMA standards.

4.7.1 Applications.- Boxes shall be provided in the wiring or raceway system for pulling wires, making connections, and mounting devices or fixtures. All outdoor boxes shall be rated minimum NEMA 3R. In hazardous areas, boxes shall be explosion proof. Each electrical outlet box shall have a machine screw which

fits into a tapped hole in the box for the ground connection. Boxes shall be sized in accordance with the NEC Article 370. Boxes for mounting lighting fixtures shall not be less than 4 inches square. Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. The front edge of the box shall be flush or recessed not more than 1/4-inch from the finished wall surface. Boxes for use in masonry-block or tile walls shall be square-cornered tile-type, or standard boxes having square-cornered tile-type covers. Cast-metal boxes installed in wet locations and boxes installed flush with exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures where required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Boxes for fixtures on suspended ceilings shall be supported independently of the ceiling supports. Boxes shall not be supported from sheet-metal roof decks. Non-metallic boxes may be used only with non-metallic raceway systems.

4.7.2 Supports.- Boxes and supports shall be securely fastened to wood with wood screws, nails, screw-type nails, carriage bolts, or lag screws of equal holding strength, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Support systems shall be capable of carrying the weight of the box and its contents. Threaded studs driven by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet-metal boxes shall be supported directly from the building structure or by bar hangers. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved fastener not more than 24 inches from the box. Penetration shall be no more than 1-1/2 inches into reinforced concrete beams nor more than 3/4-inch into reinforced concrete joists. Main reinforcing steel shall not be cut.

4.8 Wiring devices

4.8.1 Receptacles.- All receptacles shall be specification grade in accordance with NEMA STD WD-l. Unless otherwise indicated, general purpose duplex receptacles shall be specification grade, 20 ampere rating, 125 volt, grounding type NEMA 5-20R. Receptacles with push-in connections or a combination of screw-type and push-in connectors are not acceptable. Unless noted otherwise, receptacles shall be installed 12 inches above finished floor. All receptacles, unless they are of the isolated-ground type, shall be grounded by the installation of a green grounding pigtail from the receptacle grounding screw directly to the grounding screw on the outlet box where the green equipment grounding conductor is terminated.

NOTE: For all critical power circuits, the receptacles shall be twist lock type except where the receptacles are not subject to be kicked or bumped (e.g., receptacles mounted inside an equipment rack).

4.8.1.1 General.

4.8.1.2 Ground fault circuit-interrupter (GFCI) receptacles.- GFCI receptacles shall be installed in all locations required by the NEC and in other locations as indicated on the drawings. GFCI receptacles shall be 125-volt, duplex, UL Group I, Class A, rated for 20 amperes minimum. All exterior GFCI receptacles shall be mounted in weatherproof boxes with weatherproof covers.

4.8.1.3 Reserved

4.8.1.4. Isolated ground terminal receptacles.- When isolated ground terminal receptacles are shown in the contract documents, they shall be installed in accordance with Article 250-74 exception #4, of the NEC. Isolated ground terminal receptacles shall only be used where shown on the drawings. All isolated ground terminal receptacles shall be colored orange.

4.8.1.5 Plug-in strip outlets

4.8.1.5.1 General.- Fixed multi-outlet assemblies shall consist of a surface metal raceway with grounding type

receptacles. Phase and neutral conductors shall not be smaller than No. 12 AWG and shall have the type of insulation specified for branch circuit conductors. In addition, a No. 12 AWG or larger green insulated equipment grounding conductor having the same insulation as the phase conductors shall be installed. This grounding conductor shall connect all receptacle ground terminals and each section of the surface metal raceway, and shall be securely connected to the equipment grounding conductor from the branch power panel. Where more than one circuit is indicated as serving a group of similar receptacles in a common raceway, adjacent receptacles shall not be connected to the same circuit.

4.8.1.5.2 Associated hardware.- Surface metal raceways shall be provided with snap-on blank covers and/or snap-on receptacle covers for the receptacles furnished, all manufactured by the raceway manufacturer. They shall be installed to prevent open cracks. Where industry standard device plates are to be installed on raceways, snap-on blank covers shall be accurately cut to avoid open cracks. Fittings, elbows, clips, mounting straps, connection blocks, and insulators, shall be provided as required for a complete installation.

4.8.1.6 Emergency light receptacles.- Emergency light receptacles shall be grounding type single receptacles in accordance with NEMA standard WD 1.

4.8.2 Wall switches.- Single-pole and three-way wall switches shall be specification grade, rated 120/277 volts, and shall be fully rated 20 amperes, AC only. Wiring terminals shall be of the screw type. Switches with push-in connections or a combination of screw-type and push-in connections are not acceptable. Switches shall be equipped with grounding terminals and shall be grounded with a green grounding pigtail connected from the switch grounding screw directly to the grounding lug or screw on the outlet box where the green equipment grounding conductor is terminated. Switches shall be the quiet-operating type. Not more than one switch shall be installed in a single gang position.

4.8.3 Device plates.- Plates of the one-piece type shall be provided for all outlets and fittings to suit the devices installed. Plate screws shall be of metal with countersunk heads, in a color to match the finish of the

plate. Telephone and communication outlets shall be provided with a blank cover plate unless otherwise indicated. Plates shall be installed with all four edges in continuous contact with finished wall surfaces with the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed. Device plates for telephone and intercommunication outlets shall have a 3/8-inch bushed opening in the center or a dome-shaped grommet on the side.

4.8.4 Photoelectric control.- Unless otherwise indicated, photoelectric controls for floodlighting or obstruction lighting shall be 120 volt, 3000 watt, single-pole, single-throw, double-break type. Photoelectric controls shall be mounted in an appropriate weatherproof housings installed on the building exterior. The housing should be vented if possible, faced in a northerly direction. At no time shall the controllers be mounted in the same enclosure with thre batteries.

4.9 Service equipment

4.9.1 Power.- Service entrance equipment and installation for power shall be in accordance with the regulations of the local utility providing service and NEC Article 230.

4.9.1.1 Service entrance conduits.- Service entrance conduits shall be installed as shown on the drawings and shall be heavywall zinc coated rigid steel unless otherwise indicated. Grounding bushings shall be installed on both ends of the service entrance conduit.

4.9.1.1.1 Underground service.- Underground service entrance conduits shall be installed a minimum of 2 feet below finished grade. Service entrance conduit shall be electrically continuous between the service disconnecting means and the facility transformer housing. The conduit shall be bonded to the counterpoise.

4.9.1.1.2 Aerial service.- A minimum of 4 feet of slack in all service entrance conductors shall be extended from an appropriate weatherproof entrance fitting to permit connection to the service drop. Conduit shall be

concealed within the building where possible and conduit penetrations into the building shall be caulked with sealing compound.

4.9.1.2 Service disconnecting means.- Service equipment shall be a fused disconnect switch, separately mounted circuit breaker, or main circuit breaker in the main distribution panel. All switches and circuit breakers used as service entrance disconnecting means shall be UL rated for service equipment.

4.10 Panelboards

4.10.1 General.- Panelboards shall be dead-front type, shall conform to Federal Specification W-P-115, Type I, Class 1, and shall be listed by UL except for installations which require special panelboards to incorporate items not available as UL listed. Panelboards shall be mounted so that the height to the top of the panelboard shall not exceed 81 inches above the finished floor level. Unless otherwise specified, panelboards shall have a full hinged front cover with a hinged door in that cover for access to circuit breaker switches. Doors shall have flush type cylinder locks and catches. Doors over 48 inches in height shall have auxiliary fasteners on top and bottom. All locks in a project shall be keyed alike, and two keys shall be furnished with each lock. Directories shall be type written to indicate the load served by each circuit and shall be mounted on the inside of the door in a holder with a protective covering. Circuits shall be connected as indicated on the drawing. The directory shall be arranged so that the typed entries simulate circuit breaker positions in the panelboard.

4.10.2 Wiring gutters.- The minimum size of side wiring gutters shall be 4 inches for power feeders up to and including 100 amperes, 6 inches for power feeders over 100 amperes and up to 225 amperes, and 8 inches for power feeders over 225 amperes and up to 600 amperes.

4.10.3 Circuit breakers.- Circuit breaker ratings shall be in accordance with the SCA/PDC study, FAA Order 6950.27. All circuit breakers shall be UL listed thermal magnetic type or electronic solid state type, as described herein, and with a minimum rating of 10,000 AIC. Circuit breakers shall also have trip ratings,

voltage ratings, and number of poles as defined on the drawings. All circuit breakers shall have a trip indicating feature. Single-pole breakers shall be full-size modules. Two-pole and three-pole breakers shall be physically sized in even multiples of a single-pole breaker. Breakers shall be sized so that two single-pole breakers can not fit in a single housing. Multipole circuit breakers shall have an internal common trip mechanism. All circuit breakers and the panelboards in which the breakers are installed shall be products of the same manufacturer. Plug in type load centers and/or plug in type branch or feeder circuit breakers shall not be used. Positive integral locking plug-in circuit breakers, and associated panelboards, may be used.

4.10.3.1 Thermal magnetic.- All thermal magnetic breakers shall be quick make, quick break type conforming to Federal specification W-C-375. Adjustable breakers shall have setting adjustments readily accessible and visible from the front of the panel board, after installation.

4.10.3.2 Solid state.- Adjustable, solid-state or microprocessor-controlled circuit breakers shall have adjustments readily accessible and visible from the front of the panelboard, after installation. Individual circuit breaker frame size shall not exceed the panelboard bus rating.

4.10.3.3 Self enclosed circuit breakers

4.10.3.3.1 General.- Circuit breakers shall be UL listed thermal magnetic type or electronic solid state type, as described herein. Multiple circuit breakers shall have an internal common trip mechanism. Circuit breakers shall comply with Federal Specification W-C-375.

4.10.3.3.2 Thermal magnetic.- These circuit breakers shall be of the molded-case type, shall have a quick-make and quick-break toggle mechanism, inverse-time trip characteristics and shall be trip-free on overload or short-circuit. Automatic release shall be secured by a BI-metallic thermal element releasing the mechanism latch. In addition, a magnetic armature shall be provided to trip the breaker instantaneously for short-circuit currents above the overload range.

Automatic tripping shall be indicated by a handle position between the manual OFF and ON positions.

4.10.3.3.3 Solid state/microprocessor.- These circuit breakers may be used providing they meet or exceed the performance characteristics given by paragraph 4.10.3.3.2 above.

4.10.4 Bus bars.- All phase bus bars shall be copper or plated copper. Neutral and ground bus bars shall be copper or plated copper. Bus capacity shall be as indicated on the drawings. Where bus capacity is not indicated on the drawings, the capacity shall be equal to or greater than the panelboard feeder overcurrent protective device. Except as indicated paragraph 4.10.3, circuit breaker current-carrying connections shall be bolted. Bus bar connections to branch circuit breakers shall be of the sequence phase type. The neutral bus shall be insulated from all panelboards except where the panelboard is used as the service disconnecting means. Where "provisions for," "future," or "space" is noted on the drawings, the panelboard shall be equipped with bus connections for the future installation of circuit breakers.

4.10.4.1 Ground bus.- All panelboards shall have an uninsulated ground bus that is separate from the neutral bus. The ground bus shall be securely bonded to the cabinet and adequately sized for the panelboard capacity and with the number of terminations equal to the number of poles in the panelboard. The ground bus shall only be bonded to the neutral bus at the service disconnecting means. The ground bus bar shall be structurally integral to the panelboard or attached to the panelboard with a bolt, nut and lock washer. If the ground bus bar is mounted to the enclosures with screw threads only (i.e., tapped blind hole) a separate, bolted ground lug shall be installed on the panelboard and bonded to the ground bus bar. The bond conductor shall have the same current carrying capacity as the largest equipment grounding conductor terminated to the ground bus bar.

4.11 Reserved.

4.12 Safety switches.- Safety switches shall be type "HD," heavy duty, locking type unless otherwise indicated. Switches mounted in dry locations shall be

NEMA type 1 enclosures. Switches installed outdoors, or in damp locations shall be mounted in NEMA type 3R enclosures. Switches shall be of the voltage and current ratings indicated on the drawings. Switches shall be the quick-make, quick-break type. Except for ground lugs which shall be bonded to the housing, all parts shall be mounted on insulating bases to permit replacement of any part from the front of the switch. All current-carrying parts shall be of high-conductivity copper unless otherwise specified. Switch contacts shall be silver-tungsten or plated to minimize corrosion, pitting and oxidation. When used for motors a safety switch shall be sized in accordance with NEC Article 380. Switches shall disconnect all ungrounded conductors.

4.13 Cabinets.- Telephone and signal systems cabinets shall be constructed of zinc coated sheet steel in accordance with NEC Article 373-10, and shall meet the requirements of UL 50. Cabinets shall be constructed with interior dimensions not less than those indicated on the drawings. Cabinets shall be mounted so that the height to the top of the cabinet does not exceed 81 inches above the finished floor level. A locking catch and two keys shall be provided with each cabinet unless otherwise indicated. All locks in a project shall be keyed alike. Cabinets shall also be provided with a 5/8-inch plywood backboard unless otherwise indicated.

4.14 Motors and controls

4.14.1 Motors.- Motors furnished under this specification shall be of sufficient size for the duty to be performed, and shall not exceed the full-load rating when the driven equipment is operating at specified capacity. Motors shall be rated for the voltage of the system to which they are to be connected. Unless otherwise indicated, all motors shall have open frames, and continuous-duty classifications. Polyphase motors shall conform to NEMA Standard MG-1, and shall be type II, class 3, minimum insulation class B, squirrel-cage type, having normal starting-torque and low-starting-current characteristics, unless otherwise specified. When motor horsepower ratings are indicated on electrical drawings, these ratings are only approximate. Higher ratings may be required to adequately power driven equipment selected by the contractor for the duty to be performed.

4.14.2 Motor controls.- Each motor, 1/8 horsepower or larger, shall have overload protection in each phase, or other equally rated method in accordance with the NEC. The overload-protection device shall be provided either integral with the motor, or with the control, or shall be mounted in a separate enclosure. In any case the reset button shall be in an accessible location. Unless otherwise indicated, the protective device shall be of the manual reset type. Single or double-pole tumbler switches specifically designed for AC operation may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats and float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate horsepower rating. When the automatic control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for manual control.

4.14.2.1 Reduced-voltage controllers.- Reduced voltage starting methods when required shall be as indicated on the drawings.

4.14.3 Motor disconnecting means.- Each motor shall be provided with a disconnecting means and a manually operated switch as shown on the drawings or when required by the NEC. For single-phase motors, a single-pole or double-pole toggle switch, rated only for AC, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor full load amperages (FLA). Enclosed safety switches shall conform with paragraph 4.12 above.

4.15 Dry-type transformers

4.15.1 General.- Dry-type transformers shall be of the sizes and characteristics shown on drawings. Unless otherwise indicated, the design, manufacture, and testing of dry-type transformers, and the methods of conducting tests and preparing reports shall be in accordance with NEMA ST 20, and UL standards. These transformers shall be dry-type self-cooled (Class AA) as defined by ANSI/IEEE C57.12.80. Unless otherwise indicated, minimum Basic Insulation Levels (BIL) shall be in accordance with IEEE STD 141.

4.15.2 Windings and taps.- Dry-type transformers shall be provided with separate primary and separate secondary windings for each phase. The transformers shall be provided with copper windings. Unless otherwise indicated, each primary winding of each transformer rated 15 KVA and greater shall be provided with four taps, two of which shall provide 2-1/2 percent increments above full rated voltage and two of which shall provide 2-1/2 percent increments below full rated voltage. Each primary winding of each transformer rated below 15 KVA shall, be provided with not less than two taps, each providing a 5 percent increment above and below full rated voltage.

4.15.3 Insulation.- Insulation provided in transformers having ratings not exceeding 25 KVA shall have 185°C rise rating. Insulation provided in transformers having ratings exceeding 25 KVA shall have 220°C rise rating.

4.15.4 Terminal compartments.- Each dry-type transformer shall be provided with a suitable terminal compartment to accommodate the required primary and secondary wiring connections, and side or bottom conduit entrance. Transformers having ratings not exceeding 25 KVA shall be provided with terminal leads equipped with factory installed and supported connectors. Transformers rated greater than 25 KVA shall have terminal boards equipped with factory installed clamp-type connectors. The terminal compartment temperature shall not exceed 75°C when the transformer is operating continuously at rated load with an ambient temperature of 40°C.

4.15.5 Sound pressure levels and vibration isolation.- Sound pressure levels of dry-type transformers shall be determined in accordance with NEMA Standard ST 20. Levels shall not exceed 40 db for transformers rated at 9 KVA or less; 45 db for transformers rated over 9 KVA but not over 50 KVA; and 50 db for transformers rated over 50 KVA but not over 150 KVA. All dry-type transformers 45 KVA and greater shall have integral vibration isolation supports between the core and coil assembly and the transformer enclosure. Transformers of lesser rating shall have either integral or external vibration isolation supports. Conduit connections to transformers shall be made with flexible metal conduit, nominally 12 inches length but not more than 36 inches in length.

4.15.6 Enclosures.- Single-phase transformers larger than 25 KVA and three-phase transformers larger than 15 KVA shall be fully encased in steel enclosures. Transformers smaller than 15 KVA shall be fully encased in steel enclosures with or without compound fill, or shall have exposed cores, impregnated windings, and steel enclosures encircling all live parts. Enclosures shall be bonded to the grounding system. The surface temperature of the transformer shall not exceed 65°C when the transformer is operating continuously at rated load with an ambient temperature of 40°C.

4.15.7 Mounting.- Transformers shall be mounted to allow for adequate ventilation. Unless otherwise indicated on drawings, dry-type transformers having ratings not exceeding 25 KVA shall be suitable for wall mounting. Shop drawings of wall brackets and platforms for transformers shall be submitted for approval.

4.16 Identification.- Motor controllers, panelboards, safety switches and self-enclosed circuit breakers shall be identified with a name plate showing the functional name of the unit, voltage utilized, the number of phases, and other pertinent formation. Switches for local lighting need not be identified. Additional equipment shall be identified if called for on the drawings.

4.16.1 Name plates.- Name plates shall be non-ferrous metal or rigid plastic, stamped, embossed or engraved with 3/8-inch minimum height characters. The plates shall be secured to the equipment with a weather-proof bonding material or a minimum of two screws.

4.17 Fuses.- A complete set of fuses shall be installed and one set of spares shall be furnished for each fusible device. Time and current tripping characteristics of fuses serving motors or connected in series with circuit breakers shall be determined by the facility Protective Device Coordination Study (PDC). Fuses shall have a voltage rating not less than the circuit voltage. Required fuse interrupting ratings, determined by the Short Circuit Analysis (SCA) calculations, shall be as shown on the drawings, except that these interrupting ratings shall not be less than 100,000 amperes in branch and feeder circuits, and not less than 200,000 amperes in a service entrance switch.

4.18 Lamps and lighting fixtures

4.18.1 General.- Lamps and lighting fixtures shall be of the types indicated on the drawings. All lighting fixtures shall be UL approved and shall bear the UL label. All incandescent lamps shall be rated for 130 volts unless otherwise indicated. Flexible metal conduit, minimum 3/8 inch nominal trade size is permitted. External bonding jumpers are not required across the lighting fixture flexible conduit.

4.18.2 Fluorescent fixtures.- Unless otherwise indicated, fluorescent fixture lenses shall be the prismatic-type, made of virgin acrylic. Fluorescent lamps shall be rapid start, cool white unless otherwise indicated. Ballasts for fluorescent fixtures shall be class P, protected (including inherent automatic thermal reset and fuse) rapid start, high power factor type, conforming to UL Standard UL 935. Unless otherwise indicated, all ballasts shall be provided with factory installed choke-type radio frequency interference suppressers. Lampholders shall have silver plated contacts, and shall conform to standard UL 542.

4.18.2.1 Recessed fluorescent fixtures.- Recessed fluorescent fixtures shall conform to NEC Article 410-64 through 410-72, and shall be installed in suspended ceiling openings. These fixtures shall have adjustable fittings to permit alignment with ceiling panels.

4.18.2.2 Suspended fluorescent fixtures.- Pendant-mount fluorescent fixtures shall conform to Federal Specification W-F-414 and shall be of the types indicated on the drawings. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent units shall have tubing or a stem for wiring at one point, and tubing or a stem suspension provided for each unit length of chassis, including one at each end.

4.18.3 Suspended incandescent fixtures.- Pendant-mounted incandescent fixtures shall be provided with swivel hangers to insure a plumb installation.

4.18.4 Emergency lights.- Emergency lights shall conform to Federal Specification W-L-305, type I, class I, style D or E, with the number of heads as indicated on the

drawings. Emergency light sets shall be connected to the wiring system by a cord no more than 3 feet in length to a single receptacle.

4.18.5. High intensity discharge (HID) lamps.- HID lamps including mercury vapor, metal halide, and high or low pressure sodium shall be as indicated on the drawings. High power factor, constant wattage ballasts shall be furnished with HID lamps. Mercury vapor lamps shall be the color improved type.

4.19 Signal and communications

4.19.1 Entrance conduits.- Conduit materials shall be RSC unless otherwise indicated. Except where otherwise indicated, underground conduits shall be a minimum of 2 feet below finished grade and extend at least 5 feet beyond the grounding electrode system. The conduits shall be bonded to the grounding electrode system with No. 2 AWG bare copper conductor by exothermic welds or FAA-approved pressure connectors. Conduits installed for future use by others, such as for telephone, communications, electronic signals, etc., shall have both ends capped.

4.19.2 Transient protection demarcation box for electronic landlines.- A metallic, appropriately rated NEMA junction box, shall be installed where electronic landlines or conduits enter the facility. This box will house terminal boards, cables, and circuit transient protectors as shown on the contract drawings.

4.19.3 Fiber optics.- The use of fiber optics is recommended to replace metallic, control cables. Using fiber optics will eliminate outages and loss of service due to lightning strikes.

4.20 Painting and finishing.- Where factory finishes are not adequate to protect metal surfaces from corrosion, the contractor shall paint exposed surfaces prior to or after installation. All marred or damaged surfaces, except exposed metal for grounding purposes, shall be refinished to leave a smooth, uniform finish at final inspection.

4.21 Repair of existing work.- Electrical work shall be carefully planned. Where cutting, channeling, chasing,

or drilling of floors, wall partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, it shall be carefully done. The contractor shall repair, with equal material by skilled workers, any damage to facilities caused by the contractor's workers or equipment. Contracting Officer's prior approval must be obtained for the materials, workers, time of day or night, repair method, and for temporary or permanent repairs purposes. On completion, repair work shall be inspected and approved by the Contracting Officer with the concurrence of any other affected parties such as utility companies and airport authorities.

5. QUALITY ASSURANCE PROVISIONS

5.1 List of materials and equipment.- When required by the contract the contractor shall submit a list of materials and equipment to the Contracting Officer for approval.

5.1.1 Information required.- This list shall include manufacturer's style or catalog numbers. Partial lists submitted from time to time shall not be considered as fulfilling this requirement. Approval of materials will be based on manufacturer's published data. Approval of materials and equipment will be tentative, subject to submission of complete shop drawings, when required, indicating compliance with the contract documents.

5.1.2 Statement.- A manufacturer's statement indicating complete compliance with the applicable federal specification, military specification, or standards of ASTM, NEMA, or other commercial standard, is acceptable as indicating compliance with contract documents.

5.2 Shop drawings.- When required by the contract or by direction of the contracting officer, the contractor shall submit shop drawings for materials and equipment not completely identified by information submitted in the materials and equipment lists. This information shall include, but is not limited to panelboards, lighting fixtures, cable trays, switchgear, transformers, busways, cabinets, and lightning protection systems. In addition, the contractor shall provide the completed Short Circuit

Analysis/Protective Device (SCA/PDC) study, FAA Order 6950.27.

5.2.1 Coordination.- Drawings and submitted data shall be checked and coordinated with the work of other construction trades involved, before they are submitted for approval, and shall bear the contractor's stamp of approval as evidence of such checking and coordination.

5.2.2 Required data.- Drawings and submitted data shall be complete, assembled in sets and shall bear the date, drawing revision number, name of project or facility, name of contractor and subcontractor, and the clear identity of contents and location of work.

5.2.3 Approval.- The approval of drawings and submitted data shall not be construed as (1) permitting any departure from the contract requirements; (2) relieving the contractor of the responsibility for any errors, including details, dimensions, materials, etc.; or (3) approving departures from full size details furnished by the Contracting Officer.

5.2.4 Variations.- If drawings show variations from the contract requirements because of standard shop practice or for other reasons, the contractor shall describe such variations in a letter of transmittal to the Contracting Officer. If acceptable, the Contracting Officer may approve any or all such variations, subject to a proper adjustment in the contract. Contractors failing to describe such variations shall not be relieved of the responsibility for executing the work in accordance with the contract, even though such drawings have been approved.

5.2.5 Submission.- The contractor shall submit and obtain approval of shop drawings by the Contracting Officer before ordering materials or proceeding with any work associated with the shop drawings.

5.3 Tests

5.3.1 General.- Unless otherwise indicated, the contractor shall furnish all test instruments, materials and labor necessary to perform the following tests. All tests shall be performed in the presence of the Contracting Officer or his designated representative.

All instruments shall have been calibrated within a period of two years preceding testing. Calibrations shall be traceable to applicable industry recognized standards.

5.3.2 Cables.- All cables shall be tested in accordance with FAA Order 6950.22 prior to installation and again upon completion of the installation. All testing shall be accomplished before connection is made to any existing equipment.

5.3.3 Load balancing.- After the electrical installation has been completed, the contractor shall take current readings with a true RMS ammeter for the purpose of load balancing. These readings shall be taken at the service entrance, each feeder panelboard, each branch panelboard, and each separately derived source. The contractor shall redistribute single-phase loads where there is greater than a 20% difference between readings in any two phases. The contractor shall also be required to notify the Contracting Officer of current readings taken before and after installation, and any phase loaded above 80% of the rating of its overcurrent protective device.

5.3.4 Insulation resistance tests.- Feeder and branch circuit insulation tests shall be performed after installation, but before connection to fixtures or appliances. Motors shall be tested for grounds or short circuits after installation but before start-up. All conductors shall test free from short circuits and grounds, and have a minimum phase-to-phase and phase-to-ground insulation resistance of 30 megohms when measured with a 500-volt DC insulation resistance tester. Apply the test voltage for at least one minute after the meter reading has stabilized. The contractor shall submit a letter type test report to the Contracting Officer prior to final FAA inspection of the contractor's work. The report shall list the tests performed and results obtained.

5.3.5 Neutral isolation tests.- For all new installations, the neutral in the service entrance switch shall be tested for isolation from ground with an ohmmeter capable of reading greater than 20,000 ohms. This procedure to be used is detailed in the Appendix. This procedures can also be used to determine if there

are any other neutral-ground connections on the load side of the service disconnecting means.

5.3.6 Earth resistance test.- To demonstrate compliance with paragraph 4.4.4, the contractor shall measure the resistance of the grounding electrode system. Tests shall not be conducted within 48 hours of a rainfall or in frozen soil. The contractor shall immediately notify the Contracting Officer if the specified resistance is not obtained. Upon project completion, the contractor shall also submit a written test report to the Contracting Officer, defining the test procedure and results obtained.

5.3.7 Operating test.- After the interior wiring system installation is completed, and at such time as the Contracting Offer may direct, the contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the Contracting Officer or designated representative.

6. NOTES

6.1 General.- This specification is to be used as part of the contract documentation for construction and facility modification projects that do not require major design efforts. No waivers to contractors, other than those indicated as alternatives, are allowed. This specification is not to be used as a design guide. For design information, consult FAA-STD-019, Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities; FAA-STD-020, Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment; FAA Order 6950.19, Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation; FAA Order 6950.20, Fundamental Considerations for Lightning Protection, Grounding, Bonding and Shielding and other documentation as applicable.

6.2 Conflicts between documents.- In all but the smallest of modification or construction contracts, conflicts are unavoidable between the various documents cited in the contract or referenced in an included specification. Any proposal request using this document

should contain the following provisions: "Prospective contractors shall, as part of their proposals, enumerate, identify, and list conflicts that exist with the contract documents, and between those documents and the rules, regulations, and codes of the local utility company and local, county or state governing bodies."

Appendix

FACILITY NEUTRAL/GROUND ISOLATION TESTING.

The following testing is to be utilized to verify required isolation between facility neutral and ground systems within the electrical distribution system and facility equipment. Neutral grounding at the service entrance disconnect means is still required by NFPA, NEC Article 250.

EQUIPMENT NEEDED: Volt-ohm meter, flash light, allen wrenches, screw drivers, socket wrenches, and wire markers.

NOTE 1: A resistance value of greater than 20,000 ohms is the minimum value for an acceptable neutral/ground isolation test. Any lesser value indicates an unacceptable isolation condition that must be investigated.

NOTE 2: Capacitors on the neutral line or capacitive effects of the distribution system will impact resistance readings. Always use the final, stabilized readings.

NOTE 3: High impedance meters are susceptible to acting as an antenna, picking up stray fields that would not be picked up by lower impedance meters. For this series of tests, it is highly recommended that low impedance meters be used, such as an analog meter the Simpson 260 or its equivalent, or use a digital meter the Fluke 8060a series or its equivalent.

STEPS:

1. Schedule a facility outage in order to conduct the tests.

2. Review one-line diagrams of the facility electrical distribution system.

3. Isolate and lock out all standby power sources.

4. Remove facility power by opening the service disconnect means.

CAUTION: Voltage is still present at the supply side (line side) of the service entrance disconnect.

5. Verify that no voltage is present at the load side of the service disconnect means with the voltmeter using progressively lower scales.

6. Open all circuit breakers in the facility distribution system.
7. Disconnect load side neutral conductor(s).

8. Measure resistance between disconnected load side neutral conductor(s) and the service entrance enclosure ground bus.

9. If resistance reading is acceptable, reconnect neutral conductor(s) and terminate testing.

10. If resistance reading is unacceptable, tag the grounded neutral conductor(s) and leave the conductor(s) disconnected.

11. Trace the tagged conductor(s) to the load and correct the unacceptable neutral/ground bond, or to the next downstream (towards the load) neutral termination.

12. At the next downstream location, remove each load side neutral conductor one at a time and measure resistance between the conductor and the enclosure. If the resistance reading is acceptable, re-terminate the conductor. If the resistance reading is unacceptable, tag the grounded neutral conductor and leave it disconnected. Measure resistance of the rest of the neutral bus immediately after identifying a grounded conductor, to possibly verify the rest of the bus as acceptable.

13. Continue downstream as described above until all unintentional neutral/ground bonds are found and corrected.

14. Reconnect all neutral conductor(s) except at the service entrance disconnect means. Measure resistance between the load side neutral conductor(s) and the service entrance enclosure to verify successful isolation of neutral/ground conductors.

15. Reconnect neutral conductor(s), close service entrance disconnect means.

16. Place standby power source on line.

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ERROR: undefined
OFFENDING COMMAND: get

STACK:

/quit
-dictionary-
-mark-
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