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Research Buildings I, II, III Network Refresh

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Project Manual
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Construction Documents
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Divisions 21-27

HGA

Hammel, Green and Abrahamson, Inc.
1200 R Street, Suite 100
Sacramento, California 95811
(916) 787-5100

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SPECIFICATIONS

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DIVISION 01 - GENERAL REQUIREMENTS

Facility Construction Subgroup

Facility Services Subgroup

SECTION 211313
WET-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipes, fittings, and specialties.
   2. Sprinklers.

B. Scope of Work:
   1. Modification of existing sprinklers from pendent to upright orientation in rooms where the suspended ceiling is being removed. See Architectural drawings for areas where ceiling is being removed. Contractor is to verify existing conditions prior to being work.

C. Protection Limits:
   1. Provide 100 percent coverage for spaces within the limits of construction.

1.3 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

B. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

C. Grooved joint couplings and fittings shall be referred to on drawings and product submittals and shall be identified by the manufacturer's style or series designation. Trade names and abbreviations are not acceptable.

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
   1. Minimum Pipe Sizes: Pipes shall not be smaller than sizes required by NFPA 13 for connection to water supply piping, standpipes, and branches from standpipes to sprinklers.
   2. Maximum Water Velocity: Design water velocities shall not exceed 20 (FPS) feet per second in any fire protection piping.

C. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:
   a. Building Service Areas: Ordinary Hazard, Group 1.
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   e. Office and Public Areas: Light Hazard.
3. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
   d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. area.
   e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. area.
   f. Special Occupancy Hazard: As determined by authorities having jurisdiction.
4. Maximum Protection Area per Sprinkler: Per UL listing.
5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer or responsible for their preparation.
   1. Submitted working plans shall be approved by the authority having jurisdiction for wet pipe sprinkler systems.
   2. Submit hydraulic calculations when 10 or more sprinklers have been modified or added to a single system.

D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

1.7 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility.
      a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. All grooved joint couplings, fittings, valves, and specialties shall be of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
   1. All castings used for fittings, couplings, valve bodies, etc., shall include a cast date stamp for quality assurance and traceability.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.8 PROJECT CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than five days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Construction Manager's and Owner's written permission.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13.

B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

C. Delegated Design: Engage a qualified Professional Engineer, as defined in Division 01 "Quality Requirements," to design wet-pipe sprinkler systems.

1. Static and residual water pressure and water flow data shall be obtained from the local authority having jurisdiction.
2. Minimum Pipe Sizes: Pipes shall not be smaller than sizes indicated on the Drawings for connection to water supply piping, standpipes, and branches from standpipes to sprinklers.
3. Sprinkler system design shall be approved by authorities having jurisdiction.
    a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
    b. Sprinkler Occupancy Hazard Classifications:
        1) Building Service Areas: Ordinary Hazard, Group 1.
        2) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
        3) General Storage Areas: Ordinary Hazard, Group 1.
        4) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
        5) Office and Public Areas: Light Hazard.
4. Minimum Density for Automatic-Sprinkler Piping Design:
    a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
    b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
    c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
    d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. area.
    e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. area.
    f. Special Occupancy Hazard: As determined by authorities having jurisdiction.
5. Maximum Protection Area per Sprinkler: According to UL listing.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.3 STEEL PIPE AND FITTINGS

A. Schedule 40, Black Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

A. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

B. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, schedule 40, seamless steel pipe with threaded ends.

C. Galvanized and Uncoated, Steel Couplings: ASTM A 865/A 865M, threaded.

D. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

E. Cast-Iron Flanges: ASME 16.1, Class 125.

F. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Incorporated. (www.anvilintl.com)
      b. Smith-Cooper International (www.smithcooper.com)
      c. Tyco Fire & Building Products LP. (tyco-fire.com)
      d. Victaulic Company. (www.victaulic.com)
   2. Pressure Rating: 175 psig minimum.
   3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 536, ductile-iron casting; with dimensions matching steel pipe. Short pattern, with flow equal to standard pattern fittings.
   4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and ASTM A449 bolts and nuts.
      a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13. Installation ready rigid coupling for direct stab installation without field disassembly. Couplings shall be fully installed at visual pad-to-pad offset contact. Tongue and recess type couplings, which require the use of a torque wrench to achieve the exact required gap between housings, are not permitted.
      b. Flexible Type: Use in locations where vibration attenuation and stress relief are required.

2.4 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International (www.anvilintl.com)
      b. Shurjoint Piping Products (www.shurjoint.com)
      c. Tyco Fire & Building Products (www.tyco-fire.com)
      d. Victaulic Company (www.victaulic.com)
   2. Standard: UL 213.
   3. Pressure Rating: 175-psig minimum.
   4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
   5. Type: Mechanical-tee and -cross fittings.
   6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
   7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
   8. Branch Outlets: Grooved, or threaded.

2.5 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co. Inc (www.reliablesprinkler.com)
   b. Victaulic Company (www.victaulic.com)
   c. Viking Corporation (www.vikingcorp.com)
   d. Tyco Fire & Building Products (www.tyco-fire.com)

B. Sprinkler body shall be integrally cast with a hex shaped wrench boss to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss. (Sprinklers shall not contain rubber O-rings.)

C. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

D. Pressure Rating for Residential Sprinklers: 175-psig maximum.

E. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

F. Pressure Rating for High-Pressure Automatic Sprinklers: 250-psig minimum.

G. Automatic Sprinklers with Heat-Responsive Element:
   1. Early-Suppression, Fast-Response Applications: UL 1767.
   2. Nonresidential Applications: UL 199.
   3. Residential Applications: UL 1626.
   4. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

H. Sprinkler Finishes: bronze.

I. Sprinkler Guards:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Reliable Automatic Sprinkler Co. Inc (www.reliablesprinkler.com)
      b. Victaulic Company (www.victaulic.com)
      c. Viking Corporation (www.vikingcorp.com)
      d. Tyco Fire & Building Products (www.tyco-fire.com)
   2. Standard: UL 199.
   3. Type: Wire cage with fastening device for attaching to sprinkler.

J. Guards and escutcheons shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

A. Perform site investigation to confirm existing conditions. Report any major discrepancies to Architect promptly and in writing.

3.2 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install sprinkler piping with drains for complete system drainage.

G. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

H. Fill sprinkler system piping with water.

3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

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

D. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

E. 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.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints in accordance with the manufacturer's published instructions. A factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. The representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 SPRINKLER INSTALLATION

A. Sprinklers shall be located in a regular pattern, perpendicular and parallel with building lines, in perfect alignment with other ceiling components such as lights, air diffusers, grilles, and speakers.

B. Where sprinkler locations are indicated on Architectural Drawings and the coverage is inadequate, provide additional sprinklers heads located as directed by the Architect. Additional sprinklers (in excess of NFPA minimum requirements) may be required for aesthetics.

1. Sprinkler locations shall be reviewed and accepted by the Architect before any piping is fabricated or installed.
2. Adjustments in sprinkler locations shall be anticipated during shop drawing review, and shall be allowed for in the Base Bid.

C. Do not install sprinklers that have been dropped or show a visible loss of fluid. Never install sprinklers with cracked bulbs.

D. Sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.

3.5 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.8 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 8, shall be one of the following:

1. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
2. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.9 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings:
   a. Public Spaces: Concealed sprinklers.
   b. Patient and Staff Spaces: Semi-recessed.
3. Wall Mounting: Sidewall sprinklers.
4. Electrical and TDR Rooms: High temp heads with wire cage.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION

SECTION 230500

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to project piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. HVAC demolition.
5. Equipment installation requirements common to equipment sections.
6. Painting and finishing.
7. Supports and anchorages.

1.3 BASIS-OF-DESIGN

A. Equipment manufacturers listed on the equipment schedules are the basis-of-design. Manufacturers listed in the specification other than the basis-of design manufacture are acceptable substitutions. Equipment schedules are on the drawings. Refer to specifications for unscheduled equipment.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, 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 chases.

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. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Escutcheons.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Equipment startup reports.
   1. Reports will indicate equipment was started and tested according to the manufactures recommendations and is operating as specified. Included test data.

C. Coordination Drawings: Submit one copy for the engineers use. Division 23 coordination drawings will not be returned.
   1. 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. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:
      a. Planned piping layout, including valve and specialty locations and valve-stem movement.
      b. Planned piping hanger layout including building attachments and building structural coordination.
      c. Planned ductwork layout, including dampers, duct access doors, control device and specialty locations and damper movement.
      d. Planned ductwork hanger layout including building attachments and building structural coordination.
      e. Clearances for installing and maintaining insulation.
      f. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
      g. Equipment and accessory service connections and support details
      h. Exterior wall and foundation penetrations.
      i. Fire- and smoke-rated wall and floor penetration.
      j. Sizes and locations of required concrete equipment curbs and bases.
      k. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
      l. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
      m. Access door and panel locations.
      n. Reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, and other ceiling-mounted items.

D. Pre-demolition test reports.

1.7 QUALITY ASSURANCE

A. Comply with ASHRAE Guideline 4 – 2008 Preparation of operating and maintenance documentation for building systems.

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

C. 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.

D. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.8 GUIDELINES, CODES AND STANDARDS

A. Refer to the most recently published edition for references to guidelines, and standards (examples: ASHRAE, NFPA, AWWA, ASTM) unless a specific edition is listed.

B. Installation and materials shall comply with applicable national, state, and local codes and ordinances.

1.9 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 to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Deliver ducts and air handling equipment with factory or shop applied protective covering. Protective covering shall remain until installation.

D. Materials and equipment stored on site shall have a protective covering; open ends on equipment connections and ducts shall be covered. Duct liner shall be encapsulated.

1.10 COORDINATION

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

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

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

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. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 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.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 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, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

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; and AWS A5.8, BAg1, silver alloy for refrigerant piping, 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hart Industries, International, Incorporated (www.hartindustries.com)
2. Pipeline Seal and Insulator, Incorporated (Pipeline Seal and Insulator, Incorporated)
3. Watts Industries, Incorporated; Water Products Division (www.watts.com)

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

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

PART 3 EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC 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. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner only if specifically requested to be retained, by Owner, following contractor coordination with Owner prior to submission of bid. Otherwise, contractor shall dispose of materials and equipment demolished. Coordinate with Owner prior to bid.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 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, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in general locations indicated.

D. Install piping indicated to be exposed and piping in equipment and IT rooms and service areas 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 at manufacturer and code required slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Sleeves are not required for core-drilled holes through walls.

L. Verify final equipment locations for roughing-in.

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

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.

3.4 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 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.

3.5 PIPING CONNECTIONS

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

1. Install unions, in steel 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. Wet Piping Systems: Install dielectric nipple fittings to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install HVAC equipment according to the equipment manufacturer’s installation instructions and as indicated on the drawings. Resolve conflicting instructions, with the architect before mounting equipment.

B. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

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

D. Install HVAC 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.

F. Refer to equipment shop drawings for rough in locations; do not scale drawings.

3.7 SEALANTS

A. Comply with joint-sealant materials and applications specified in Section 078400 “Firestopping,” Section 078443 “Fire-resistant Joint Sealants,” Section 079000 “Joint Protection,” and Section 092900 “Gypsum Board: Acoustical sealants.”

3.0 CYBERSECURITY RISK MITIGATION STRATEGY

A. Coordinate with Owner’s IT Department to restrict external network access to Internet connected system through virtual private network (VPN) connections only.

B. Security Event Log: Coordinate with the Owner to configure security event logging. Access to security logs shall be limited to users with proper authentication. Security logs shall be time stamped with Time and Date metadata for auditing and back-up.

C. Disable any protocols for remote connectivity, unless constantly required for day-to-day operations.

D. All external transport data shall be routed through encrypted channels with 2048-bit secure sockets layer (SSL).

E. Coordinate with Owner’s IT Department to implement a Web server-based human machine interface (HMI) that relies on IT technologies to secure access and restrict ports that can be opened on the firewall. Coordinate with Owner’s IT Department to restrict access to known IP addresses only.

F. Where building system networks are not physically separate from IT business networks, coordinate with Owner’s IT Department to segregate networked and Internet connected systems from the IT business network using virtual local area network (VLAN) IT technologies to restrict internal attacks/breakdowns.

G. Set unique, cryptographically strong passwords for administrator and user accounts. Default passwords must be changed before systems are connected to the Owner’s network.

H. Collect only the data that is necessary for analytics and optimization.

I. References:

1. NIST Special Publication 800-14 – Generally Accepted Principles and Practices for Securing Information Technology Systems.
2. NIST Special Publication 800-54 Revisions 4 – Security and Privacy Controls for Federal Information Systems and Organizations.
3. Defense Security Service Office of the Designated Approving Authority – Master System Security Plan (MSSP) Template for Peer-to-Peer Networks (June 2011, Version 3.0.).
4. IEC 62443: Industrial Network and System Security.

3.1 RESPONSIBILITY MATRIX (RECOMMENDED)

A. The responsibility matrix is a partial list of items requiring coordination and is only a recommendation to the contractor. The contractor is responsible for the complete installation and operation of equipment and materials.

B. Refer to Division 22 Section “Common Work results for Plumbing” for additional requirements.

C. Key:

1. BAS Building Automation System (Temperature Control Installer)
2. FP Fire Protection (Division 21)
3. PLBG Plumbing Installer (Division 22)

4. HVAC Mechanical Installer (Division 23)
5. E Electrical Installer (Division 26)
6. D Data/Communication Cabling Installer (Division 27)
7. O Other

System Description	Furnished By	Installed By	Wired/Piped By
Network			
LAN wiring to 1st tier supervisory TCP's	D	D	D
BAS 2nd tier (N2 Bus) communication wiring	BAS	BAS	BAS
Control Power			
120v power to DDC panels	E	E	E
120v power to VAV air terminal transformer panel	E	E	E
120v circuit breaker to DDC Panel	E	E	E
Control Wiring			
DDC panel input/output wiring	BAS	BAS	BAS
Room Temperature Sensor wiring	BAS	BAS	BAS
Combination Fire/Smoke Damper			
Combination fire/smoke damper(s)	HVAC	HVAC	-
Electric actuator	HVAC	HVAC	E
120V to fire/smoke damper(s)	E	E	E
Fire alarm system interlock signal	E	-	-

END OF SECTION

SECTION 230518

ESCUTCHEONS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed and exposed-rivet hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install escutcheons for exposed piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.
g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

2. Escutcheons for Existing Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal Framing Systems
4. Equipment supports.

B. Related Sections:

1. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

B. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Manufacturers: Subject to compliance with requirements provide products by one of the following:
      a. Allied Tube & Conduit. (www.alliedtube.com)
      b. Cooper B-Line, Inc. (www.cooperindustries.com)
      c. Flex-Strut Inc. (www.flexstrut.com)
      d. Thomas & Betts Corporation. (www.tnb.com)
      e. Unistrut Corporation; Tyco International, Ltd. (www.unistrut.com)
      f. Wesanco, Inc. (www.wesanco.com)
   2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   3. Standard: MFMA-4.
   4. Channels: Continuous slotted steel channel with in-turned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.6 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors 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 attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. 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.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.4 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
    2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
    3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

P. Use powder-actuated fasteners instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.
8. Ceiling ID markers

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

E. Ceiling tag identification for review and confirmation with Architect and owner.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch or 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number. Coordinate/verify label content with owner.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data..

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 thick, and having predrilled holes for attachment hardware.

B. Letter Color: Refer to ANSI standards.

C. Background Color: Refer to ANSI standards.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

1. Pretensioned Pipe Labels: Precoiled, semi rigid plastic formed cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
2. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
    a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
    b. Lettering Size: At least 1-1/2 inches high for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
3. All pipes 1” and larger shall have size identification at the same locations as service identification markers.

2.4 DUCT LABELS

A. General Requirements for Manufactured duct Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Self-Adhesive Duct Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

1. Stencil Paint: Exterior, gloss acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
2. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

B. Stencils for Piping:

1. Lettering Size: According to ASME A13.1.
2. Stencil Material: Fiberboard or metal.

C. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

D. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass (0.032-inch minimum thickness) or plastic laminated and engraved (0.06 inch minimum thickness), and having predrilled or stamped holes for attachment hardware.
2. Tag Size: 1 inch x 2 inches or 2” round
3. Fasteners: Brass wire-link or beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 4 by 7 inches minimum
2. Fasteners: Brass grommet and wire.

3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

2.8 CEILING ID MARKERS

A. Clear adhesive label with bold black lettering (font size 16) with equipment, etc., ID information.

B. 5/8-inch diameter celluloid tack that can be printed or written on.
   1. Color code as follows:
      a. HVAC valves and cocks: Yellow
      b. Air modulating devices (i.e. balancing dampers): Aluminum
      c. Fire dampers, smoke dampers, fire protection valves: Red
      d. VAV controllers, duct static pressure sensors: Green

PART 3 EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles complying with ASME A13.1 on each piping system.
   1. Identification Paint: Use for contrasting background.
   2. Stencil Paint: Use for pipe marking.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 30 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

C. Pipe Label Color Schedule:
   1. Heating Water Piping:
      a. Background Color: Green
      b. Letter Color: White
   2. Refrigerant Piping:
      a. Background Color: Blue
      b. Letter Color: White

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Green: For outside-, relief-, return-, and mixed-air ducts.
   4. Red: for exhaust air ducts
   5. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Direction Flow Arrows: Arrow shall be used to indicate direction of flow in ducts.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.
   1. At both side of each penetration through walls, floors, ceilings and inaccessible enclosures.
   2. For identification of fire dampers, smoke dampers and combination fire and smoke dampers.

D. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 2 inch high is needed for proper identification because of distance from normal location of required identification.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Refrigerant: 1-1/2 inches, round.
      b. Hot Water: 1-1/2 inches, round.
   2. Valve-Tag Color:
      a. Refrigerant: Natural
      b. Hot Water: Natural
   3. Letter Color:
      a. Refrigerant: White
      b. Hot Water: White

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.7 CEILING-TAG INSTALLATION

A. For equipment (VAV boxes, fans, fan coil units, equipment, filters, etc.) and branch isolation valves located above suspended ceilings, label ceiling grid (not the tile) at key access points with a clear adhesive label with bold black lettering (font size 16) with equipment, etc., ID information.

END OF SECTION

SECTION 230593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
   a. Constant-volume air systems.
2. Verifying that automatic control devices are functioning properly.
3. Reporting results of activities and procedures specified in this Section.

1.3 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 sub mains, 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. NC: Noise criteria.

E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

F. RC: Room criteria.

G. Report Forms: Test data sheets for recording test data in logical order.

H. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

I. Test: A procedure to determine quantitative performance of systems or equipment.

J. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

K. AABC: Associated Air Balance Council.

L. TAB: Testing, adjusting, and balancing.

M. TABB: Testing, Adjusting, and Balancing Bureau.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Sample Report Forms: Submit two sets of sample TAB report forms.

G. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

H. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC.
   1. TAB Technician: Employee of the TAB contractor and who is certified by AABC as a TAB technician.

B. Balance agency shall be a member of Associated Air Balance Council. Subject to compliance with requirements, balance agency shall be one of the following: (no others will be considered). Balance agency shall be approved by University prior bid.
   1. MESA^3
   2. RS Analysis
   3. Raglen System Balance

C. Coordination of documentation and communication flow. 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.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

F. 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.

1.6 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 minimum of 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. 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:
   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.

B. Study design specifications and engineering Drawings and prepare schedule to psychically inspect mechanical equipment for hydronic and air distribution systems to be tested and balanced. Contractor shall provide balance agency with one copy of Contract Drawings and specifications, mechanical equipment submittals, and change orders necessary for proper balancing of air distribution systems.

C. Prepare test and balance schedule, test record forms, and necessary technical information about hydronic and air distribution systems for installed heating-cooling equipment.
   1. Provide written documentation when the above notated items have been completed, (Example Checklist provided at the end of this section.) A single page letter signed off by the Mechanical Contractor and Test and Balance Agency will suffice.

D. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

E. Examine the approved submittals for HVAC systems and equipment.

F. 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.

G. Examine equipment performance data including fan and pump curves.
   1. 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.

H. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

I. Balance agency shall make field inspections prior to closing in portions of systems to be balanced. Agency shall verify to its satisfaction that all work, fittings, dampers, balancing devices, etc. are properly fabricated and installed as shown or specified and that agency will be able to properly balance system.

J. Recommend adjustments and/or corrections to mechanical equipment and hydronic and air distribution systems that are necessary for proper balancing of systems.
   1. Provide written documentation of the recommended items to the Architect for review.

K. Examine test reports specified in individual system and equipment Sections.

L. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

M. 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 the following:
   1. Equipment and systems to be tested.
   2. Strategies and step-by-step procedures for balancing the systems.
   3. Instrumentation to be used.
   4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work and prepare reports. Include, at a minimum, the following:
   1. General:
      a. Permanent electrical-power wiring is complete.
      b. Automatic temperature-control systems are operational.
      c. Windows and doors can be closed so indicated conditions for system operations can be met.
   2. Airside:
      a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
      b. Duct systems are complete with work performed as noted within documents.
      c. Clean filters are installed.
      d. Fans are operating, free of vibration, and rotating in correct direction.
      e. Variable-frequency controllers' startup is complete and safeties are verified.
      f. Automatic temperature-control systems are operational.
      g. Ceilings are installed, where applicable.
      h. Suitable access to balancing devices and equipment is provided.

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 Total System Balance" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 "Air Duct Accessories."
   2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 "Duct Insulation," Division 23 "HVAC Equipment Insulation," and Division 23 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material 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. As-built drawings of existing systems will be made available to the installing contractor and testing agency upon request.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge.

E. Check dampers for proper position to achieve desired airflow path.

F. Check for airflow blockages.

G. Verify that air duct system is sealed as specified in Division 23 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow as may be needed to perform work.
      a. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
      b. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
   2. Review Record Documents to determine adjustments to accommodate actual conditions.
   3. Do not make fan-speed adjustments that result in motor overload.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   1. Measure airflow of submain and branch ducts.
      a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   2. Adjust submain branch duct volume dampers for specified airflows.
   3. Re-measure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values.
   1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
   2. Measure inlets and outlets airflow.
   3. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
      a. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
   4. Re-measure each inlet and outlet after they have been adjusted.

E. Verify final system conditions.
   1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
   2. Re-measure and confirm that total airflow is within design.
   3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
   4. Mark all final settings.
   5. Measure and record all operating data.
   6. Record final fan-performance data as may be applicable to perform scope of work noted.

3.6 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: 0 to plus 5 percent.
   2. Air Outlets and Inlets: 0 to minus 5 percent. (unless otherwise allowed in writing by engineer of record)

3.7 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a pre-construction report of existing airflows and a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices. Submit all reports to Architect for review upon completion.

B. Status Reports: As work progress prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors. Submit all reports to Architect for review upon completion.

3.8 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. 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; do not include Shop Drawings and product data.
5. Provide air balance summary in table format for each room listing, including, at a minimum:
   a. Room number*
   b. Room name*
   c. Room volume*
   d. Air handling equipment serving the room (ie AHU-2, CAV-4, etc)*
   e. Required air charge rate per CMC table 4A (Outside air, supply, return, and/or exhaust, as applicable.)*
   f. Required cfm per CMC table 4A (Outside air, supply, return, and/or exhaust, as applicable.)*
   g. Scheduled Supply air, exhaust air, and return air cfm9s) per project documents.*
   h. Actual air supply air, exhaust air, and return air cfm(s) per air balance report.
   i. Actual air change rate (supply, return and/or exhaust, as applicable).
   j. Actual outside air percent, cfm, and air change rate.
   k. Pressure relationship (P, N, NR) and percentage negative or positive.

‘*’ Information available within project documents.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
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 supervisor 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's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, 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. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. 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 outdoor, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet neck sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. 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 degrees F.
    d. Duct static pressure in inches w.g.
    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.

F. Instrument Calibration Reports:

1. Report Data:
    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.9 VERIFICATION OF TAB REPORT

A. Initial Verification:

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. Check the following for each system:
    a. Measure airflow of at least 10 percent of air outlets.

b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Verification:

1. After initial verification is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final verification be made by Architect.
2. The TAB contractor's test and balance engineer shall conduct the verification in the presence of Architect or authorized representative.
3. Architect or authorized representative shall randomly select measurements, documented in the final report, to be rechecked. 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 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 and request a second final inspection.
7. If the second final verification also fails, Owner may contract the services of another TAB specialist to complete the testing, adjusting, and balancing in accordance with the Contract Documents and deduct the cost of the services from the original TAB specialist’s final payment.
8. If the second verification also fails, Owner or design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.

C. Prepare test and inspection reports.

3.10 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

END OF SECTION

SECTION 230713

DUCT INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, duct systems modified and installed per work scope as follows:
   a. Indoor, existing concealed supply.
   b. Indoor, new concealed supply.
   c. Indoor, existing concealed return located in unconditioned space.
   d. Indoor, new concealed return located in unconditioned space.
   e. Indoor, existing concealed exhaust if insulated.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Insulation shall be installed by a licensed insulation contractor, not the mechanical or plumbing contractor. Submit License information within submittal package.

C. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required. Insulation application may begin on segments that have satisfactory test results.

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FRK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Friendly Feel Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; SOFTR All-Service Duct Wrap.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to it and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-127. Eagle Bridges - Marathon Industries; 225.
      b. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 85-60/85-70. Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 85-50. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.4 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 428 AWF ASJ.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
   c. Compac Corporation; 104 and 105.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40-lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40-lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34-lbf/inch in width.

2.5 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ITW Insulation Systems; Gerrard Strapping and Seals.
      b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
   2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with closed seal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.105 inch diameter shank, length to suit depth of insulation indicated.
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; CWP-1.
         2) GEMCO; CD.
         3) Midwest Fasteners, Inc.; CD.
         4) Nelson Stud Welding; TPA, TPC, and TPS.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.105 inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2 inch galvanized carbon-steel washer.
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; CHP-1.
         2) GEMCO; Cupped Head Weld Pin.
         3) Midwest Fasteners, Inc.; Cupped Head.
         4) Nelson Stud Welding; CHP.

C. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

D. Wire: 0.062 inch soft-annealed, stainless steel
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. C & F Wire.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

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

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3 inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
   1. Comply with requirements in Section 078400 "Firestopping".

D. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078400 "Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 75 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
   3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
      a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      d. Do not over compress insulation during installation.
      e. Impale insulation over pins and attach speed washers.
      f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
   4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2 inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
      a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
      b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18 foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
   5. Overlap unraced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
   6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
   7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6 inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply.
   2. Indoor, concealed return located in unconditioned space.
   3. Indoor, concealed exhaust.
   4. Existing duct repairs shall match existing system insulation and minimum energy code requirements.

3.7 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, rectangular, round, and flat-oval, plenum and supply-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Concealed, rectangular, round, and flat-oval, plenum and supply-air duct located in unconditioned spaces; insulation shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

C. Concealed, rectangular, round, and flat-oval, plenum and return-air duct located in unconditioned spaces; insulation shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, rectangular, round, and flat-oval, plenum and outdoor-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, rectangular, round, and flat oval, plenum and exhaust-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

END OF SECTION

SECTION 230719

HVAC PIPING INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Condensate drain piping, indoors.
   2. Heating hot-water piping, indoors
   3. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Products: Subject to compliance with requirements provide one of the following:
   a. Aeroflex USA, Inc.; Aerocel. (www.aeroflexusa.net)
   b. Armacell LLC; AP Armaflex. (www.armacell.com)
   c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS. (www.kflexusa.com)
2. Thermal conductivity (k-value) at 75 degrees F is 0.28 Btu x in. /h x sq. ft. x degrees F or less.

G. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Fibrex Insulations Inc.; Coreplus 1200. (www.fibrex.com)
   b. Johns Manville; Micro-Lok. (www.jm.com)
   c. Knauf Insulation; 1000-Degree Pipe Insulation. (www.knaufinsulation.us)
   d. Manson Insulation Inc.; Alley-K. (www.isolationmanson.com)
   e. Owens Corning; Fiberglas Pipe Insulation. (commercial.owenscorning.com)
2. Type I, 850 degrees F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   a. Thermal conductivity (k-value) at 150 degrees F is 0.27 Btu x in. /h x sq. ft. x degrees F or less.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 degrees F.

1. Products: Subject to compliance with requirements provide one of the following:
   a. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 81-84. (www.fosterproducts.com)
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements provide one of the following:
   a. Aeroflex USA, Inc.; Aeroseal. (www.aeroflexusa.net)
   b. Armacell LLC; Armaflex 520 Adhesive. (www.armacell.com)

c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 85-75. (www.fosterproducts.com)
d. K-Flex USA; R-373 Contact Adhesive. (www.kflexusa.com)

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-127. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 225. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 85-60/85-70. (www.fosterproducts.com)
d. Mon-Eco Industries, Incorporated; 22-25. (www.mon-ecoindustries.com)
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-82. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 225. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 85-50. (www.fosterproducts.com)
d. Mon-Eco Industries, Incorporated; 22-25. (www.mon-ecoindustries.com)
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements provide one of the following:
a. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 30-80/30-90. (www.fosterproducts.com)
b. Vimasco Corporation; 749. (www.vimasco.com)
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-30. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 501. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 30-35. (www.fosterproducts.com)
d. Mon-Eco Industries, Inc.; 55-10. (www.mon-ecoindustries.com)
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 degrees F.

4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; Encacel. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 570. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 60-95/60-96. (www.fosterproducts.com)
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 degrees F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-10. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 550. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 46-50. (www.fosterproducts.com)
d. Mon-Eco Industries, Inc.; 55-50. (www.mon-ecoindustries.com)
e. Vimasco Corporation; WC-1/WC-5. (www.vimasco.com)
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625 inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.4 SEALANTS

A. Joint Sealants:
1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-76. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 405. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 30-45. (www.fosterproducts.com)
d. Mon-Eco Industries, Inc.; 44-05. (www.mon-ecoindustries.com)
e. Pittsburgh Corning Corporation; Pittseal 444.
2. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-70. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 405. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 30-45. (www.fosterproducts.com)
d. Mon-Eco Industries, Inc.; 44-05. (www.mon-ecoindustries.com)
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 degrees F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-76. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 405. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; 95-44. (www.fosterproducts.com)
d. Mon-Eco Industries, Inc.; 44-05. (www.mon-ecoindustries.com)

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H.B. Fuller Company; CP-76. (www.idccorp.com)
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
   a. covers for lavatories.

C. Metal Jacket:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems. (www.idccorp.com)
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing. (www.itwinsulation.com)
   c. RPR Products, Inc.; Insul-Mate. (www.rprhouston.com)
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Sheet and roll stock ready for shop or field sizing.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
   d. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.6 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements provide one of the following:
   a. ABI, Ideal Tape Division; 428 AWF ASJ. (www.abitape.com)

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836 (www.stus.averydennison.com)
c. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ (www.venturetape.com)
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements provide one of the following:
a. ABI, Ideal Tape Division; 491 AWF FSK (www.abitape.com)
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827 (www.stus.averydennison.com)
c. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ (www.venturetape.com)
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements provide one of the following:
a. ABI, Ideal Tape Division; 488 AWF (www.abitape.com)
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800. (www.stus.averydennison.com)
c. Venture Tape; 3520 CW. (www.venturetape.com)
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.7 SECUREMENTS

A. Bands:
1. Products: Subject to compliance with requirements provide one of the following:
a. ITW Insulation Systems; Gerrard Strapping and Seals. (www.itwinsulation.com)
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs. (www.rprhouston.com)
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with closed seal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

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

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3 inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install 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 o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078400 "Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078400 "Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2 inch laps at longitudinal seams and 3 inch wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where metal jackets are indicated, install with 2 inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum jackets.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Degrees F:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 3/4 inch thick.

B. Heating-Hot-Water Supply and Return, 105 degrees to 140 degrees F:
   1. NPS 1.5 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1.5 inches thick.
   2. NPS 2 and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I, 2 inches thick.

C. Heating-Hot-Water Supply and Return, 130 degrees to 200 degrees F:
   1. NPS 1.25 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1.5 inches thick.
   2. NPS 1.5 and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I, 2 inches thick.

D. Refrigerant Suction and Hot-Gas Flexible Tubing:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Flexible Elastomeric: 1 inch thick.
      b. Polyolefin: 1 inch thick.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Flexible Tubing:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Flexible Elastomeric: 2 inches thick.

END OF SECTION

SECTION 232300

REFRIGERANT PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig.
   2. Suction Lines for Heat-Pump Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Hot-gas bypass valves.
   4. Filter dryers.
   5. Strainers.
   6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
   1. Shop Drawing Scale: 1/8 inch equals 1 foot.
   2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.

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

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

D. Brazing Filler Metals: AWS A5.8.

E. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Non-rotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. End Connections: Socket, union, threaded, or flanged.

6. Maximum Opening Pressure: 0.50 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

F. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: [Adjustable] [Nonadjustable].
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig.

G. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

H. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh Monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

I. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: at rated system tonnage.
9. Working Pressure Rating: 500 psig.

10. Maximum Operating Temperature: 240 deg F.

J. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: at rated system tonnage.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

2.3 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Atofina Chemicals, Incorporated.
2. DuPont Company; Fluorochemicals Division.
3. Honeywell, Incorporated; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

F. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

G. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

H. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

I. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

3.3 PIPING INSTALLATION

A. 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 Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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

D. Install piping indicated to be exposed and piping in equipment rooms and service areas 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 adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

M. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Liquid lines may be installed level.

N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

P. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.

C. Support multi-floor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.

D. Perform the adjustments before operating the refrigeration system in accordance with manufacturer's written instructions:

END OF SECTION

SECTION 233113

METAL DUCTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Fittings.
4. Reinforcement and spacing.
5. Seam and joint construction.
6. Penetrations through fire-rated and other partitions.
7. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
8. Hangers and supports, including methods for duct and building attachment and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

1.4 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers:
    a. Ductmate Industries, Incorporated
    b. McGill AirFlow Corporation.
    c. Semco Incorporated.
    d. Sheetmetal Connectors Incorporated.
    e. Spiral Manufacturing Company

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: 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: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 4 inches.
   3. Sealant: Modified styrene acrylic.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   3. Shore A Hardness: Minimum 20.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.
   1. General: Single-component, acid-curing, silicone, elastomeric.
   2. Type: S.
   3. Grade: NS.
   4. Class: 25.
   5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1," Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Duct dimensions indicated on drawings are clear airway dimensions. Overall duct dimensions to be increased to account for duct liner thickness in order to maintain clear airway dimensions.

C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

D. Install ducts in maximum practical lengths.

E. Install ducts with fewest possible joints.

F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

K. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:
      a. Supply Ducts with a Pressure Class of higher than 2-Inch wg: Test all duct sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
      b. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test all duct sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
      c. Exhaust Ducts with a Pressure Class of 1-Inch wg or Higher: Test all duct sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   3. Leak test each section of duct within a concealed shaft regardless of pressure class.
   4. Test for leaks before applying external insulation.
   5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
   6. Give seven days' advance notice for testing.

C. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for ducts with a Duct Pressure Classification greater than 2-inches, and for Leakage Class 6 for ducts with duct pressure classification 2-inches or less.
      a. For a duct section with greater than 2-inch Duct Pressure Classification, leakage shall not exceed 7.5 CFM per 100 sq. ft. of duct surface area.
      b. For a duct section with a 2-inch Duct Pressure Classification and Duct Leakage Class 6, leakage shall not exceed 9.5 CFM per 100-sq. ft. of duct surface area.
      c. For positive pressure exhaust ducts, leakage shall be zero at 4.0 inches wg.

D. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

E. Duct system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.8 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:
   1. Ducts Connected to Fan Coil Units, Heat Pumps, Terminal Units and Transfer Air.
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round: 6.
   2. Downstream Ducts Connected to Rooftop Units (RTU’s):

a. Pressure Class: Positive 4-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3.
d. SMACNA Leakage Class for Round: 3.

3. Downstream Ducts Connected to Variable Air Volume Boxes (VAV's):
   a. Pressure Class: 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round: 6.
4. Downstream Ducts Connected to RTU-2 Supply Air Valves (SV's):
   a. Pressure Class: 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round: 6.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round: 6.
2. Ducts Connected to Rooftop Units (RTU's):
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round: 6.
3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round: 6.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative: 2-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round: 6.
2. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
   a. Type 316, stainless-steel sheet.
      1) Exposed to View: No. 4 finish.
      2) Concealed: No. 2D finish.
   b. Pressure Class: Negative, 4 inch wg.
   c. Minimum SMACNA Seal Class: Welded seams and joints.
   d. Airtight/Watertight.
3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Velocity 1000 fpm or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 1000 to 1500 fpm :
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
   c. Velocity 1500 fpm or Higher:
      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.
3. See drawing details for additional requirements.

END OF SECTION

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Combination fire and smoke dampers.
3. Turning vanes.
4. Remote damper operators.
5. Duct-mounted access doors.
6. Flexible ducts.
7. Duct accessory hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. 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.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers: Maximum velocity 1500 fpm.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Balance Incorproated; a Division of Mestek, Incorporated. (www.airbalance.com)
      b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
      c. Flexmaster U.S.A., Incorporated. (www.flexmasterusa.com)
      d. McGill AirFlow LLC. (www.mcgillairflow.com)
      e. Nailor Industries Incorproated. (www.nailor.com)
      f. Pottorff. (www.pottorff.com)
      g. Ruskin Company. (www.ruskin.com)
      h. Trox USA Incorporated. (www.troxusa.com)
      i. Vent Products Company, Incorporated. (www.ventproducts.com)
   2. Standard leakage rating, with linkage outside airstream.
   3. Maximum air velocity: 1500 fpm.
   4. Suitable for horizontal or vertical applications.
   5. Frames:
      a. Frame: 5-inches wide, Hat-shaped, 0.064-inch- thick, galvanized sheet steel with reinforced corners.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   6. Blades:
      a. Multiple or single blade.
      b. 6-inches wide.
      c. Parallel- or opposed-blade design.
      d. Stiffen damper blades for stability.
      e. Galvanized-steel, 0.064 inch thick.
   7. Blade Axles: ½-inch Galvanized steel.
   8. Bearings:
      a. Molded synthetic.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle’s full length of damper blades and bearings at both ends of operating shaft.
   9. Tie Bars and Brackets: Galvanized steel.

B. Standard, Steel, Manual Volume Dampers: Maximum air velocity 3,000 fpm.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
      b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
      c. Flexmaster U.S.A., Inc. (www.flexmasterusa.com)
      d. McGill AirFlow LLC. (www.mcgillairflow.com)

e. Nailor Industries Incorporated. (www.nailor.com)
f. Pottorff. (www.pottorff.com)
g. Ruskin Company. (www.ruskin.com)
h. Trox USA Incorporated. (www.troxusa.com)
i. Vent Products Company, Incorproated. (www.ventproducts.com)

2. Standard leakage rating, with linkage outside airstream.
3. Maximum air velocity: 3000 fpm.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Frame: 5-inches wide, Hat-shaped, 0.064-inch- thick, galvanized sheet steel with reinforced corners.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. 6-inches wide.
   c. Parallel- or opposed-blade design.
   d. Double skin air foil damper blades.
   e. Galvanized-steel, 0.078 inch thick.
7. Blade Axles: ½-inch Galvanized steel.
8. Bearings:
   a. Stainless steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle's full length of damper blades and bearings at both ends of operating shaft.
9. Tie Bars and Brackets: Galvanized steel.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.3 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
2. Cesco Products; a Division of Mestek, Incorporated. (www.cescoproducts.com)
3. Greenheck Fan Corporation. (www.greenheck.com)
4. Nailor Industries Incorporated. (www.nailor.com)
5. Pottorff. (www.pottorff.com)
6. Ruskin Company. (www.ruskin.com)

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

1. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
2. Fire Rating: 1-1/2 and 3 hours. Refer to drawings.
3. Frame: Hat-shaped, 0.063-inch- thick, galvanized sheet steel, with welded and mounting flange.
4. Heat-Responsive Device: Resettable, 165 deg F rated fusible links.
5. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.
6. Blades: Roll-formed, horizontal, overlapping, 0.063-inch-thick, galvanized sheet steel.
7. Leakage: Class I.
8. Rated pressure and velocity to exceed design airflow conditions.
9. Mounting Sleeve: Factory-installed, 0.039-inch-thick, galvanized sheet steel; length to suit wall or floor application.
10. Damper Motors: Two-position action.
11. Damper Motors: Modulating action – For RTU-1 return air at each floor to control and maintain floor at slight positive pressure.

12. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
    c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
    d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
    e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
    f. Non-spring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
    g. Electrical Connection: Refer to Division 26 drawings.
13. Accessories:
    a. Momentary test switch with remote mounting, see detail within drawings and coordinated with other trade contractors.

2.4 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Incorporated. (www.ductmate.com)
   2. Elgen Manufacturing. (www.elgenmfg.com)
   3. Nexus PDQ; Division of Shilco Holdings Incorporated. (www.nexuspdq.com)

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
   1. Material: Galvanized steel.
   2. Gage and Shape: Match connecting ductwork.

2.5 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Incorporated. (www.ductmate.com)
   2. Elgen Manufacturing. (www.elgenmfg.com)
   3. Sheetmetal Connectors Incorporated. (www.smcduct.com)

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
   1. Vane Construction: Single and Double wall.
   2. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.6 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Pottorff. (www.pottorff.com)
   2. Ventfabrics, Incorporated. (www.ventfabrics.com)
   3. Young Regulator Company. (www.youngregulator.com)

B. Description: Cable system designed for remote manual damper adjustment.
   1. Tubing: Aluminum.
   2. Cable: Stainless stee.
   3. Wall-Box Mounting: Recessed.
   4. Wall-Box Cover-Plate Material: Steel.

2.7 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
   2. Cesco Products; a Division of Mestek, Incorporated. (www.cescoproducts.com)
   3. Ductmate Industries, Incorporated. (www.ductmate.com)
   4. Elgen Manufacturing. (www.elgenmfg.com)
   5. Flexmaster U.S.A., Incorporated. (www.flexmasterusa.com)
   6. Greenheck Fan Corporation. (www.greenheck.com)
   7. McGill AirFlow LLC. (www.mcgillairflow.com)
   8. Nailor Industries Incorporated. (www.nailor.com)
   9. Pottorff. (www.pottorff.com)
   10. Ventfabrics, Incorporated. (www.ventfabrics.com)

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. Vision panel.
      d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
      e. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   3. Number of Hinges and Locks:
      a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
      b. Access Doors up to 18 Inches Square: Two hinges or Continuous and two sash locks.
      c. Access Doors up to 24 by 48 Inches: Three hinges or Continuous and two compression latches with outside and inside handles.
      d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.8 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Pottorff. (www.pottorff.com)
   2. Ruskin Company. (www.ruskin.com)

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.9 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flexmaster U.S.A., Incorporated. (www.flexmasterusa.com)
2. McGill AirFlow LLC. (www.mcgillairflow.com)
3. ThermaFlex (www.thermaflex.net)

B. Insulated-Flexible Duct: UL 181, Class 1, heavy-coated fiberglass cloth liner supported by helically wound, spring-steel wire. Fiberglass insulation R-4.2 with aluminized vapor barrier.

1. Pressure Rating:
   a. Sizes 2-inches to 10-inches: 16-inch wg positive and 1.0-inch wg negative.
   b. Sizes 12-inches to 20-inches: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 20 to plus 250 Degrees
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
2. Apply adhesive tape over outer vapor barrier.

2.10 DUCT ACCESSORY HARDWARE

1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install manual volume dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff. Install manual volume dampers as indicated on the Drawings and Details, and as necessary to accomplish system air balancing. As a minimum, manual volume dampers will be provided at every divided flow main or branch duct, at every branch duct take off, and every duct extending to individual register, grille, or diffuser. Manual volume dampers are not required upstream of variable volume air terminal units.

1. Install steel volume dampers in steel ducts.
2. Install remote damper operators for volume dampers located above gypsum board, plaster, and other hard ceilings.
3. Set dampers to fully open position before testing, adjusting, and balancing.

D. Install test holes at fan inlets and outlets and elsewhere as indicated.

E. Install combination fire/smoke dampers according to manufacturer's UL-approved written instructions. Refer to the architectural drawings for fire rating requirements. Provide 1-1/2 hour rated dampers for wall and floor assembles rated for less than 3 hours. Provide 3 hour rated combination dampers for wall and floor assembles rated for 3 hours or more. Combination dampers will have 165-degree F links except as noted.

1. Refer to the combination fire/smoke damper schedule for additional data.

2. Coordinate the installation of duct smoke detectors provided by Division 26. Duct smoke detectors must be installed in an accessible location in accordance with the manufacturer's instructions and the UL listing.

F. Connect ducts to duct silencers with flexible duct connectors.

G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. Downstream from control dampers, backdraft dampers, and equipment.
   2. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
      a. At each change in direction and at maximum 50-foot spacing.
      b. Upstream and downstream from turning vanes.
      c. Upstream or downstream from duct silencers.
      d. Control devices requiring inspection.
      e. Elsewhere as indicated.
   3. Install access doors with swing against duct static pressure.
   4. Access Door Sizes:
      a. One-Hand or Inspection Access: 8 by 5 inches.
      b. Two-Hand Access: 12 by 6 inches.
      c. Head and Hand Access: 18 by 10 inches.
      d. Head and Shoulders Access: 21 by 14 inches.
      e. Body Access: 25 by 14 inches.
      f. Body plus Ladder Access: 25 by 17 inches.
   5. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

H. Installation of Flexible Ducts
   1. Install flexible ducts according to the manufacturer's instructions, applicable SMACNA standards, drawing details, and as follows:
      a. Duct Collars: Provide tap-in collars 4-inches minimum in length with a formed bead 1-inch from the end for attachment of flexible duct. Extend minimum collar length for manual volume dampers.
      b. Connections: Attach flexible duct to the tap-in collars and to sleeves with a duct clamp (draw band) around the inner liner and a second draw band around the insulation jacket. Position duct clamps behind the beads on the collar or sleeve. Duct clamps may be screwed stainless steel bands or nylon straps tightened with a compression tool.
      c. Duct Supports: Support flexible duct at the manufacturer's recommended interval, but not less than every 5 feet. Maximum permissible sag is 1/2-inch per foot of spacing between supports (maximum of 1-1/4-inches over five feet).
      d. Duct Hangers: Provide hanger straps in contact with the flexible duct at least 2-inch wide so the internal diameter of the duct is not reduced at the point of support.
      e. Duct Bends: Make bends or turns in flexible ducts with not less than a one-duct diameter throat radius.
      f. Connect diffusers, registers, grilles, and light troffer boots to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place. Refer to drawing details for additional requirements.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Install duct test holes where required for testing and balancing purposes.
6. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 233713

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Rectangular and square ceiling diffusers.
   2. Modular core supply grilles.

B. Related Sections:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, mounting surface, border, frame, and accessories furnished.

1.4 COORDINATION

A. Review the architectural drawings for diffuser, register, and grille mounting surfaces.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Price Industries.
      b. Titus.
      c. Krueger.
      d. Nailor Industries Inc.
   2. Accessories: Refer to the drawings and equipment schedules for accessories.

B. Louver Face Diffuser:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Price Industries.
      b. Titus.
      c. Krueger.
      d. Nailor Industries Inc.
   2. Accessories: Refer to the drawings and equipment schedules for accessories.
      a. Throw reducing vanes.

2.2 REGISTERS AND GRILLES

A. Fixed Face Register:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Price Industries.
      b. Titus.
      c. Krueger.
      d. Nailor Industries Inc.
   2. Material: Steel.
   3. Finish: Baked enamel, white.
   4. Face Arrangement: Refer to register schedule.
   5. Frame: Minimum 20 Gauge Steel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

C. Provide the appropriate mounting frame or border for each diffuser register or grille location. Verify ceiling grid type for lay-in type inlets and outlets. Non-lay-in diffusers, registers, and grilles will have frames or borders for surface mounting.

3.2 INSTALLATION

A. Diffuser, register, and grille sizes and locations are indicated on the drawings and schedules.

B. Install diffusers, registers, and grilles level and plumb.

C. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical.

D. Install diffusers, registers, and grilles with airtight connections to ducts.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 238126

SPLIT-SYSTEM HEAT PUMPS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes split-system heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

C. Field startup reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system heat pump units to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.7 COORDINATION

A. Coordinate sizes and locations of mounting conditions with actual equipment provided.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

A. Limited Warranty Period

1. STANDARD FIVE (5) YEAR WARRANTY FOR A QUALIFIED SYSTEM - The Part(s) of a qualified System, including the compressor, are warranted for a period (the "Standard Parts Warranty Period") ending five (5) years after the date of original installation. In absence of proof of installation, the warranty date will end five (5) years from the date of manufacture.

1.9 DELIVERY STORAGE AND HANDLING

A. Deliver, store, protect and handle under the supervision of the owner and in accordance with the manufacturer's Operation & Maintenance manuals.

1.10 COORDINATION

A. Coordinate sizes and locations of assembly with mounting conditions represented within the contract drawings.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. LG

B. Mitsubishi

C. Carrier

D. Or Equal Manufacturer

2.2 PRODUCT DESIGN

A. The Single zone HVAC system shall be a variable capacity, direct expansion (DX) heat pump system consisting of a single outdoor unit and single indoor unit. The outdoor unit shall have a single inverter compressor. The outdoor unit (ODU) shall be connected to the indoor unit (IDU) with piping and control wiring.

B. The LG heat pump system shall be an air-cooled system consisting of a single outdoor unit connected to a single indoor unit.

C. Single zone system requires the indoor unit to be piped with the outdoor unit to complete the refrigeration system

D. The heat pump system will be available in 208/230V, 60Hz, 1 phase.

2.3 OPERATING CONDITIONS

A. The outdoor units shall be capable of the following ambient operating range.

1. Cooling: 14°F DB to 118°F DB
2. Heating: 14°F WB to 65°F WB

B. The indoor units shall be capable of the following ambient operating range.

1. Cooling: 53°F WB to 75°F WB
2. Heating: 60°F DB to 86°F DB

2.4 GENERAL - OUTDOOR UNITS

A. Unit shall be manufactured by LG.

B. The air-conditioning system shall use R410A refrigerant.

C. The system shall have one air source outdoor unit.

D. The refrigerant circuit shall be field piped to a single matching indoor unit to effectively and efficiently control the heating or cooling operation of the system.

E. All refrigerant piping from outdoor unit to indoor unit shall be field insulated.

F. Factory installed microprocessor controls in the outdoor unit and indoor unit shall perform functions to efficiently operate the single zone system and communicate via minimum 18 AWG, 4 conductor, stranded, shielded or unshielded power/communication cable. If shielded, it must be grounded to chassis at ODU only.

G. The outdoor unit shall be internally assembled, wired and piped from the factory.

H. The factory assembled system shall have the outdoor unit fitted with refrigerant strainer, check valves, oil separator, accumulator, 4-way reversing valve, electronic expansion valve, high side and low side refrigerant charging ports, and a service port.

I. Piping Capabilities

1. The outdoor unit shall be capable of operating at an elevation of 98.4 feet above or below the indoor units.
2. The outdoor unit shall be capable of operating with up to 164 feet of total equivalent refrigerant piping length.

J. Defrost Operations

1. The outdoor unit shall be capable of auto defrost operation to melt accumulated ice off the outdoor unit heat exchanger. The defrost cycle control shall be based on outdoor ambient temperatures and outdoor unit heat exchanger temperatures.

K. Oil Management

1. The outdoor unit shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts at low speed.
2. The outdoor unit shall have an oil separator to separate oil mixed with the refrigerant gas during compression and return oil to the compressor.

L. Cabinet

1. The outdoor unit cabinet shall be made of pre-coated metal (PCM).
2. The front/side panels of the outdoor unit shall be removable type for access to internal components.
3. Outdoor unit cabinet shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.

M. Fan Assembly

1. The outdoor unit shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a horizontal air discharge.
2. The fan blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
3. The fan shall be equipped with permanently lubricated bearings.
4. The fan motor shall have variable speed to a maximum of 950 RPM.
5. The fan shall have a raised guard to help prevent contact with moving parts.

N. Outdoor Coil

1. The outdoor unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. The aluminum fins shall have factory applied corrosion resistant GoldFin™ material.
3. Coil coating shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
4. The outdoor unit coil shall be factory tested to a pressure of 600 psig.
5. The coil for each outdoor unit shall have a minimum of 14 Fins per Inch (FPI).
6. The coil for each outdoor unit shall have a 2 row heat exchanger.
7. The outdoor unit cabinet shall have a coil guard.

O. Compressor

1. Each 1.5 to 3 ton outdoor unit (LSU243 HLV1) shall be equipped with one hermetically sealed, digitally controlled, inverter driven twin-rotary compressor.
2. The compressor shall be mounted on vibration attenuating rubber grommets.
3. The compressor shall use a factory charge of Polyvinyl Ether (PVE) oil.
4. The compressor bearing(s) shall have Teflon™ coating.
5. The compressor shall be equipped with over-current protection.

P. Sound Levels

1. The outdoor unit shall have sound levels not exceeding 57 dB(A) tested in an anechoic chamber under ISO 3745 standard.

Q. Sensors

1. The outdoor unit shall have
2. Suction temperature sensor
3. Discharge temperature sensor
4. High pressure sensor
5. Low Pressure sensor
6. Outdoor temperature sensor
7. Outdoor unit heat exchanger temperature sensor

R. Wind Load Installations for Outdoor Units

1. LG FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010.

2.5 GENERAL- INDOOR UNITS

A. Unit shall be manufactured by LG.

B. Unit shall be factory assembled, wired, piped and run tested.

C. Unit shall be designed to be installed for indoor application.

D. Unit shall be attached to an installation plate/bracket that secures unit to the wall.

E. The depth of the unit shall not exceed 10 inches.

F. Casing/Panel

1. Unit case shall be manufactured of heavy-duty Acrylonitrile Butadiene Styrene (ABS) and High Impact Polystyrene (HIPS) plastic.
2. Unit case shall have a pearl white finish.
3. The front surface of the unit shall have an architectural curved panel with pearl white finish.

G. Cabinet Assembly

1. Unit shall have one supply air outlet and one return air inlet.
2. Unit shall be equipped with factory installed temperature thermistors for
   a. Return air
   b. Refrigerant entering coil
   c. Refrigerant leaving coil
3. Unit shall have a built-in control panel to communicate with the outdoor unit.
4. Unit shall have the following functions as standard
   a. Self-diagnostic function
   b. Auto restart function
   c. Auto changeover function
   d. Auto clean function
   e. Dehumidifying function
   f. Hot Start
   g. Sleep mode
5. Unit shall be capable of refrigerant piping in 4 different directions.
6. Unit shall be capable of drain piping in 2 different directions.

H. Fan Assembly
   1. The unit shall have a direct drive, cross flow fan made of high strength ABS plastic.
   2. The fan motor is Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
   3. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
   4. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
   5. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Power Cool, and Auto.
   6. In heating mode, the indoor fan shall have the following settings: Low, Med, High, Power Heat and Auto.
   7. The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.
   8. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.

I. Filter Assembly
   1. The return air inlet shall have a factory supplied removable, washable filter.
   2. The filter access shall be from the front of the unit.

J. Coil Assembly
   1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
   2. Unit shall have minimum of 2 rows of coils.
   3. Unit shall have a factory supplied condensate drain pan below the coil constructed of HIPS (high impact polystyrene resin).
   4. Unit shall be designed for gravity drain.
   5. Unit shall have a factory insulated drain hose to handle condensate.
   6. Unit shall have provision of 45° flare refrigerant pipe connections
   7. The coil shall be factory pressure tested at a minimum of 551 psig.
   8. All refrigerant piping from outdoor unit to indoor unit shall be field insulated.

K. Microprocessor Control
   1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
   2. The unit shall be able to communicate with the outdoor unit using a field supplied minimum of 18 AWG, 4 conductor, stranded, shielded or unshielded power/communication cable. If shielded, it must be grounded to chassis at ODU only.
   3. The unit controls shall operate the indoor unit using one of the five operating modes:
      a. Auto changeover
      b. Heating
      c. Cooling
      d. Dry
      e. Fan only

L. Electrical
   1. The LS---HLV1 electrical power shall be 208-230/1/60 (V/Ph/Hz)
   2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

M. Condensate Sensor Connection
   1. The unit shall include a factory installed condensate sensor connection compatible with the AquaGuard® AG-9300-LG condensate sensor.

N. Controls
   1. The indoor unit shall be supplied with a wireless handheld controller. Handheld controller shall be installed within wall bracket secured to wall.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation and other conditions affecting performance of system, equipment, and work.

B. Examine roughing-in for refrigerant piping systems, electrical, and controls services to verify actual locations of connections before installation.

3.2 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports as detailed within drawings. Anchor units to supports.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
2. Comply with requirements for vibration isolation devices as detailed in drawings.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.3 CONNECTIONS

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

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 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.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Provide Owner a minimum of 2-weeks' notice of desired training dates and times.

END OF SECTION

SECTION 260500

ELECTRICAL WORK – GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 CONDITIONS:

A. The Requirements of General Conditions and Special Conditions apply to Work of this Section as if fully repeated herein.

B. Drawings and specifications take precedence when they call for materials or construction methods of better quality or larger size than required by codes laws, rules, or regulations.

C. The Requirements of this Section apply to all Work of Division 26.

1.2 WORK INCLUDED:

A. Provide a complete working installation with all material and equipment as shown and specified. The Contract Documents do not undertake to show or specify every item to be provided. When an item not shown or specified is necessary for proper operation of equipment shown or specified, provide the item, which will allow the system to function properly, at no increase in Contract Price.

B. Make electrical connections for equipment furnished as part of Work of other Sections.

C. Perform necessary equipment seismic anchorage in compliance with the California Building Code Title 24.

D. The drawings indicate the arrangements of electrical equipment. Review architectural drawings and details for door swings, cabinets, counters, and built-in equipment; conditions indicated on architectural plans shall govern. Coordinate installation of electrical equipment with structural system and mechanical equipment and access thereto. Coordinate installation of recessed electrical equipment with concealed ductwork and piping, and wall thickness.

E. Equipment layout is based on one manufacturer's product or from composite dimensions from multiple manufacturers. Where equipment selected for use on the job differs from layout, coordinate space requirements and connection arrangements with Engineer. Equipment which exceeds specified maximum dimensions, or which reduces required clearances shall not be accepted.

1.3 QUALITY ASSURANCE:

A. Requirements of Regulatory Agencies:
   1. As specified in Division 1 - General Requirements.
   2. Nothing in the Contract Documents shall be construed to permit Work not conforming to applicable laws, ordinances, rules, or regulations.
   3. When the Contract Documents exceed requirements of applicable laws, ordinances, rules or regulations, Contract Documents shall take precedence.

4. It is not the intent of the Contract Documents to repeat requirements of Codes except where necessary for completeness or clarity.
5. All installed or connected equipment shall be labeled or certified for its use by a nationally recognized testing laboratory. Where equipment is not furnished with a factory installed label or certification, it shall be the responsibility of the contractor to obtain and pay for the necessary tests and approvals.

1.4 SUBMITTALS:

A. General:

1. Submit Shop Drawings and supplemental data for all materials and equipment specified in all Sections of this Division, in accordance with the Requirements of Division 1, and as specified hereinafter.
2. Submittals shall have materials proposed for the project identified. Catalog cuts containing unidentified materials or superfluous information will not be accepted.
3. All submittals shall be reviewed by the Contractor and stamped with his approval prior to submitting to the Architect. Contractor shall indicate in writing any deviation in submittals from requirement of Contract Documents.
4. Forward all submittals to the Architect, together, at one (1) time. Individual or incomplete submittals will not be acceptable. Only one (1) request for substitution will be considered on each item of materials or equipment.
5. Wherever catalog numbers and specific brands or trade names, not preceded by the designation "equal to", or followed by the designations "or equal", "or accepted equal", or "or approved equal", are mentioned in these Specifications or Drawings, no substitutions will be accepted.
6. Identify each item by manufacturer, brand, trade name, number, size, rating, or whatever other data is necessary to properly identify and check materials and equipment. The words "as specified" will not be sufficient identification.
7. Identify each submittal item by reference to Specification Section paragraph in which the item is specified or Drawing and Detail number.
8. Organize submittals in binders, in the same sequence as they appear in Specification Sections, article or paragraphs.
9. Shop Drawings shall show physical arrangement, construction details, finishes, materials used in fabrication, provisions for conduit entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and weight. Reuse of the Contract Drawings as Shop Drawings will not be acceptable.
    a. Specifically show, by drawn detail or note, that equipment complies with each specified requirements of the Contract Documents.
    b. Drawings shall be to scale and dimensioned (except wiring diagrams need not be to scale) and may be prepared by a vendor but shall be submitted as instruments of Contractor, thoroughly checked, and stamped by Contractor before submission to Architect for review.
    c. Catalog cuts and published material may be included to supplement scale drawings.
10. Internal wiring diagrams of equipment shall show wiring as actually furnished for this project, with all optional items clearly identified as included or excluded. Clearly identify external wiring connections. Identify and obliterate superfluous material.
11. External system wiring diagrams shall show wiring as actually installed, connected, and identified for this project. Include identification of cables, cable conductors, terminals in

terminal cabinets, and connections to the identified external wiring connection points on equipment. Prepare Drawings on twenty-four inches (24") by thirty-six inches (36") minimum sheets bearing title block of equipment manufacturer, manufacturer's local engineering distributor, or Contractor, prepared to accepted drafting standards, and bearing Contractor's approved stamp.

12. Acceptance of a substitute is not to be considered a release from the Specifications. Correct any deficiencies in an item, even though approved, at Contractor's expense.
13. Be responsible for installation of approved substitution. Make any changes required for installation of approved substituted equipment at no increase in Contract Sum.

B. Operating and Maintenance Instructions and Materials:

1. After final completion and testing operations, part of the Work of this Division shall be responsibility for instructing the Owner's authorized representatives in operation, adjustment, and maintenance of electrical plant. Submit three (3) copies of certificate, signed by Owner's representatives, attesting to their having been instructed.
2. Before Owner's personnel assume operation of systems, submit three (3) bound sets of Operating and Maintenance Instructions, Manuals, and Parts Lists on the electrical plant and its component parts, including all major equipment and that which requires or for which manufacturer recommends maintenance in a specified manner. Provide names, addresses and telephone numbers of source of supply for parts.

1.5 PROJECT RECORD DOCUMENTS:

A. Upon completion of Work, furnish Architect with complete sets of reproducible plans upon which shall be shown all Work installed under Contract. Drawings shall include actual locations of outlets, conduit, and wire sizing as well as routing and revised panelboard schedules.

B. All symbols and designations used in preparing Record Drawings shall match those used in Contract Drawings.

C. Maintain an up to date set of electrical drawings during the course of construction.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Identify materials and equipment delivered to site to permit check against materials list and Shop Drawings.

B. Protect from loss or damage. Replace lost or damaged materials and equipment with new at no increase in Contract Sum.

1.7 PROJECT EXAMINATION AND CONDITIONS:

A. Examine project; verify dimensions and locations against Drawings and become informed of all conditions under which Work is to be done before submitting proposals.

B. Information shown relative to services is based upon available records and data but shall be regarded as approximate only. Make deviations found necessary to conform with actual locations and conditions with no increase in Contract Sum. Verify locations and elevation of utilities prior to commencement of excavation for new underground installations.

C. Exercise extreme care in excavating near existing utilities to avoid any damage thereto; be responsible for any damage caused by such operations.

1.8 DRAWINGS AND COORDINATION WITH OTHER WORK:

A. Drawings:
   1. For purposes of clarity and legibility, Drawings are essentially diagrammatic to the extent that many offsets, bends, special fittings, and the exact locations of items are not shown, unless specifically dimensioned.
   2. Exact routing of wiring and locations of outlets, panels, and other items, shall be governed by structural conditions, and materials and equipment already in place. Use data in the Contract Documents. In addition, the Architect reserves the right, at no increase in Contract Sum, to make any reasonable change in locations of exposed electrical items, to group them into orderly relationships and/or increase their utility. Verify the Architect's requirements in this regard prior to roughing-in.
   3. Dimensions, locations of doors, partitions and similar physical features shall be taken from Architectural Drawings and verified at the site as part of the Work of this Division. Consult the Architectural Drawings for exact location of outlets to center with architectural features, panels, and similar items, at the approximate locations shown on the Electrical Drawings.
   4. Drawings indicate, generally, routes of all branch circuits. All runs to panels are indicated as starting from nearest outlet, pointing to direction of panel. Continue all such circuits, conduits to panel as though routes were indicated in their entirety.

B. Coordination:
   1. Work out all "tight" conditions involving Work of this Division and Work of other Divisions in advance of installation. Provide additional Work necessary to overcome "tight" conditions, at no increase in Contract Sum.
   2. Differences of disputes concerning coordination, interference or extent of Work between Divisions shall be decided by General Contractor. His decision, if consistent with Contract Document requirements, shall be final.
   3. Provide adequate working space around electrical equipment in compliance with all applicable codes.
   4. Coordinate electrical interface of mechanical equipment with the Work of Division 22 & 23.
   5. Provide templates, information, and instructions for Work of other Divisions to properly locate holes and openings to be cut or provided for Electrical Work.
   6. Size all feeders (conduit and wiring), motor starters, overload protection and circuit breakers to suit horsepower of motors or wattages of equipment furnished as part of the Work of the various Sections of the Specifications. In no case shall feeders and branch circuits (conduit and wiring) and circuit breakers be of smaller capacities or sizes than those shown or specified.
   7. Schedule of Work - Refer to Section on Work Sequence.
   8. Make every effort to keep existing electrical circuits, including telephone, public address, fire alarm, power, and other electrical services, in operation. Where power outages are unavoidable, schedule such outages with the Owner to occur at such times as to cause the least disruption of normal facility functions.

C. Equipment Rough-In:

1. Rough-in locations shown on Electrical Drawings for equipment furnished by the Owner and for equipment furnished under other Divisions are approximate only. Obtain exact rough-in locations from the following sources:
    a. From Shop Drawings for Contractor-furnished and installed equipment.
    b. From the Architect for Owner-furnished, Contractor-installed equipment.
    c. From the Architect for existing equipment where such equipment is relocated as part of the Work of this Contract.
2. Verify electrical characteristics of equipment before starting rough-in.
3. Unless otherwise shown or specified, equipment which requires electrical connection shall be installed as part of the Work of the Division in which specified. Internal components shall be wired to a single point with wiring in raceway direct connection (hardwired) to building electrical system or internal wiring and connections with cord and plug for receptacle connection to building wiring.
4. Unless otherwise shown or specified, provide direct raceway and conductor connections from building wiring system to equipment terminals for direct connected equipment which is Contractor-furnished and Contractor-installed, Owner-furnished and Contractor-installed, and for existing equipment relocated by the Contractor.
5. Insert plug in receptacle for cord-connected equipment which is Contractor-furnished and Contractor-installed, Owner-furnished and Contractor-installed and for existing equipment relocated by the Contractor. Provide new cord and plug if required on Owner-furnished and Contractor-installed equipment.
6. Provide disconnect switches, flush type in finished spaces, where shown or required by Codes for direct-connected equipment.
7. Disconnect existing equipment from building electrical system, including internal wiring required for relocation and reconnection at new location.

1.9 GUARANTEE:

A. Provide guarantee in accordance with and in form required under Division 1. Repair or replace as may be necessary any defective work, material, or part with no increase in Contract Sum including repair or replacement of other Work, furnishing, equipment or premises caused by such repair or replacement of defective work.

1. Where other guarantee periods or requirements are called for in other sections of the contract documents, they shall take precedence over the requirements of Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. Identify materials and equipment by manufacturer's name and nameplate data. Remove unidentified materials and equipment from site.

B. Equipment specified by manufacturer's number shall include all accessories, controls, and other components, listed in catalog as standard with equipment. Furnish optional or additional accessories as specified. All materials shall be UL labeled and in accordance with NEMA Standards.

C. Where no specific make of material or equipment is mentioned, any high-quality product of a reputable manufacturer may be used, provided it conforms to requirements of system and meets with Architect's acceptance.

D. Conflicts between Plans and Specifications, exclusive of the General Conditions of the Contract, the most stringent and higher quality requirement shall govern.

E. If the Contract Documents are not complete as to any detail such as accessories or hardware, of a required construction system or with regard to manner of installing of parts, materials, or equipment, but there exists an accepted trade standard for good and workmanlike construction, such detail or accessories shall be deemed to have been implicitly required by the Contract Documents in accordance with such standard.

F. Equipment and material damaged during transportation, installation, or operation will be considered as totally damaged. Replace with new. Variance from this will be permitted only with written acceptance.

G. Provide an authorized representative to constantly supervise the Work of this Division and to check all materials prior to installation for conformance with the Contract Documents.

H. Do not use equipment exceeding dimensions indicated for equipment, or arrangements that reduce required clearances, or exceed specified maximum dimensions.

2.2 FLASH PROTECTION

A. Electrical equipment including switchboards, panelboards, disconnect switches, etc. which are likely to require examination, adjustment or servicing while energized shall be field marked to warn of potential electric arch flash hazards per CEC Article 110.16. Marking shall be a pre-printed label which references NFPA 70E.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Manufacturer's Directions: Follow manufacturer's directions where manufacturers of articles used furnish directions covering points not specified or shown.

B. Equipment: Accurately set and level, neatly place support and anchor properly.

C. Assemble all equipment which requires assembling including Contractor-supplied bussing, internal wire connections where required; connect all incoming conduit, cable, and wires properly; and adjust and make ready for service electrical equipment and material required by this Contract.

D. All Work shall be done in orderly, workmanlike manner in accordance with NECA Standard of Installation and present neat appearing installation when completed.

E. Provide concrete pads for floor mounted electrical equipment.

1. Install minimum 4” high concrete pads, and a minimum of 2” beyond the equipment dimensions or as indicated. Other pad dimensions shall be as required to accommodate the equipment installed.
2. Use 3,000 PSI concrete.
3. Reinforce with 6” x 6” 10GA wire mesh with short dowels into floor at 12” on center around perimeter.
4. Chamfer top edges ¾”.
5. Make all faces smooth.
6. Set anchor bolts for equipment.
7. Coordinate the size of all pads and the location of all structural embedment requirements for anchor bolts and any vibration isolators.
8. Multi-wire branch circuits are not permitted. Provide dedicated neutrals for all branch circuits.

3.2 NORMAL CONTINGENCIES:

A. Protection: In performance of Work, protect existing facility and protect Work of other Sections as well as Work of this Section from damage.
   1. Existing conduits which are required to be extended, altered, or reconnected shall be accomplished as shown or as directed. Existence of any wires, conduits, or other facilities are shown in a general way only. Determine existence, location, and condition on site.
   2. Where existing conduits which are shown to be revised or which will be essential to functioning of particular system are cut or exposed due to construction changes, new connections shall be made in most expeditious manner as directed or shown. Where wiring is involved, new wires shall be "pulled-in" between nearest available accessible reused outlets. In all cases where new wires are required, shown, or specified to be installed in existing conduits, if same cannot be installed, new conduits shall be provided therefore as directed.
   3. Existing switchboards, motor control centers, and panelboards which are required to be extended, altered, or modified under the Work of this Division shall be provided with new sections, bus extensions, and all necessary hardware for a complete and operating system.
   4. Attention is called to the fact that all new conduit, wiring, and apparatus shown or specified shall be connected to existing systems so as to function as complete units.
   5. All conduits, electrical apparatus, and similar items, in place and not shown or specified to be reused or which will not be essential to functioning of various systems when Work is completed, shall be removed. No existing material shall be reinstalled or reused, unless shown or specified. Concealed conduits which are not shown or specified to be reused and become exposed due to construction changes shall be removed to nearest available accessible reused outlets.

3.3 PERFORMANCE:

A. Sleeves, Chases, and Concrete Inserts:
   1. This Division shall provide, to cause no delay, all required sleeves, chases, concrete inserts, anchor bolts, and similar items before concrete is placed, and be responsible for correct location and installation of same.
   2. Sleeves and chases are prohibited in structural members, except were shown or as otherwise approved in writing.

B. Cutting and Patching:
   1. Do all cutting and patching, including structural reinforcing, necessary for the Work of this Division.
   2. No reinforcing steel or pre-stressed tendons may be cut within concrete floors without prior approval. All new cores or drilled holes shall be a minimum of 1 ½" clear of existing reinforcing. Concrete slabs must be scanned to determine the location of all reinforcing steel prior to coring, anchorage, drilling or any other modifications.
   3. Do no cutting or patching without prior approval. Repair damage done by cutting and patching equal to original condition, in Architect's opinion.

C. Provide metal backing plates, anchor plates, and similar items that are required for anchorage for the Work of this Section; securely weld or bolt to metal framing. Wood blocking or backing will not be permitted in combination with metal framing.

3.4 TESTING AND ADJUSTING:

A. Furnish all labor and test equipment required for the Work of this Division. Testing work is defined as that work necessary to establish that equipment has been properly assembled, connected, and checked to verify that intent and purpose of the drawings, specifications, manufacturer's instruction manuals, and directions of Architect have been accomplished in satisfactory manner.

B. Provide field tests to verify component compliance with Specifications, including but not limited to adjusting, calibrating, and setting circuit breakers, relays, timers, etc.

C. After completion of testing and adjustment, operate the different systems and equipment under normal working conditions and show specified performance. If, in the opinion of the Architect, performance of equipment or systems is not in accordance with Contract Document or submitted data, alter, or replace equipment at no increase in Contract Sum.

D. Do not allow or cause any Work installed hereunder to be covered up or enclosed before it has been inspected and accepted. Should any Work be enclosed or covered up before it has been approved, uncover such Work, and after it has been inspected and approved, make all repairs necessary to restore Work of Others to condition in which it was found at time of cutting, all at no increase in Contract Sum.

E. At completion of Work provide written certification that all Systems are functioning properly without defects.

3.5 CLEANING AND PAINTING:

A. Properly prepare Work of this Division to be finish painted as part of the Work of Painting Section.

B. Refinish Work supplied with final finish as part of the Work of this Division if damaged as part of the Work of this Division to satisfaction of Architect.

C. Thoroughly clean interiors of switchboards and motor control centers. After other Work is accomplished, clean exposed conduit, panels (interiors and exteriors), fixtures, and equipment, and leave in condition satisfactory to Architect.

D. Clean out and remove from site all surplus materials and debris resulting from this Work, including surplus excavated materials.

END OF SECTION

SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes building wire and SO cable with insulation rated 600 volts and less; and wiring connectors and connections.

B. Related Sections:
   1. Section 26 05 53 - Identification for Electrical Systems: Product requirements for wire identification.

1.2 REFERENCES

A. International Electrical Testing Association:
   1. ANSI/NETA ATS – 2017 Acceptance Testing Specifications for Electrical Power Equipment and Systems.

B. NECA (National Electrical Contractors Association) - Standard of Installation.

C. ANSI/NFPA 70 – National Electrical Code (NEC).

D. Part 3, Title 24, - California Electrical Code (CEC).

E. Underwriters Laboratories, Inc. (UL).
   1. UL-83, UL-44 – Thermoplastic-Insulated Wire and Cables.

1.3 SYSTEM DESCRIPTION

A. Product Requirements: Provide products as follows:
   1. Stranded conductor for feeders and branch circuits 10 AWG and smaller.
   2. Stranded conductors for control circuits.
   3. Conductor not smaller than 12 AWG for power and lighting circuits. The minimum size of emergency system conductors shall be 10 AWG.
   4. Conductor not smaller than 16 AWG for control circuits.
   5. 10 AWG conductors for 20 amperes, 120-volt branch circuit home runs longer than 75 feet.
   6. 10 AWG conductors for 20 amperes, 277-volt branch circuit home runs longer than 200 feet.
   7. Cables shall be jacketed 600 volts SO type.

B. Wiring Methods: Provide the following wiring methods:
   1. Concealed Dry Interior Locations: Use only building wire, Type THHN/THWN-2 or XHHW-2 insulation, in raceway.
   2. Exposed Dry Interior Locations: Use only building wire Type THHN/THWN-2 or XHHW-2 insulation, in raceway.
   3. Exterior Locations: Use only building wire Type THHN/THWN-2 or XHHW-2 insulation, in raceway.

4. Underground Locations: Use only building wire Type THHN/THWN-2 or XHHW-2 insulation, in raceway.
5. Cord Drops: Use 600 volt 'SO' cable was indicated on drawings.

1.4 SUBMITTALS

A. Product Data: Submit for building wire and each cable type.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of components and circuits.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

1.7 FIELD MEASUREMENTS

A. Verify field measurements are as indicated on Drawings.

1.8 COORDINATION

A. Where wire and cable destination are indicated and routing is not shown, determine routing and lengths required.

B. Determine required separation between wire, cable, and other work. Determine cable routing to avoid interference with other work.

C. Wire and cable routing indicated is approximate unless dimensioned.

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Manufacturers:
1. Diamond Wire & Cable Co.
2. Essex Group Inc.
3. General Cable Co.
4. Approved equal.

B. Product Description: Single conductor 600 volt insulated wire.

C. Conductor: Copper.

2.2 ELECTRICAL INSULATING TAPE:

A. Electrical insulating tape shall be 600-volt, flame retardant, cold and weather resistant, minimally .85 mil thick plastic vinyl material: Scotch No. 88, Tomic No. 85, Permacel No. 295, or equal.

2.3 INSULATING RESIN:

A. Use two-part liquid epoxy resin with resin and catalyst in premeasured, sealed mixing pouch. Scotchcast 3570G or equivalent.

2.4 REDUCING ADAPTERS:

A. Burndy, Thomas, and Betts or approved equal.

2.5 WIRING CONNECTORS

A. Bolted pressure connectors: Cast bronze compression bolts designed for parallel taps, tees, crosses, or end-to-end connections.

B. Insulated spring wire connectors (No. 10 AWG and smaller): multi-part construction incorporating a steel spring enclosed with a color coded outer thermoplastic shell.

C. Insulated spring wire wet/damp location spring wire connectors: multi-part construction incorporating a steel spring enclosed with a color coded outer thermoplastic shell pre-filled with silicone base to protect against moisture and corrosion.

D. Splices, taps and connectors (No. 8 AWG and larger): Burndy, T & B, or equal Tin-plated copper high-compression type lugs for installation with hand or hydraulically operated crimping tools and dies. Provide 2-hole lugs for size #4/0 AWG and larger wire were terminated to bus bars.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify interior of building has been protected from weather.

B. Verify mechanical work likely to damage wire and cable has been completed.

C. Verify raceway installation is complete and supported.

3.2 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.

3.3 EXISTING WORK

A. Remove exposed abandoned wire and cable, including abandoned wire and cable above accessible ceiling finishes. Patch surfaces where removed cables pass through building finishes.

B. Disconnect abandoned circuits and remove circuit wire and cable. Remove abandoned boxes when wire and cable servicing boxes is abandoned and removed. Install blank cover for abandoned boxes not removed.

C. Provide access to existing wiring connections remaining active and requiring access. Modify installation or install access panel.

D. Extend existing circuits using materials and methods as specified.

E. Clean and repair existing wire and cable remaining or wire and cable to be reinstalled.

3.4 INSTALLATION

A. Route wire and cable to meet Project conditions.

B. Neatly train and lace wiring inside boxes, equipment, and panelboards.

C. Splices in homerun conductors to panelboards, switchboards, switchgear, motor control centers, motor control enclosures, and other panels shall be kept to the minimum practicable and shall only be made as necessary to support pulling of the conductors. Make splices in conductors only within junction boxes, wiring troughs and other enclosures as permitted by the California Electrical Code.

D. Do not splice conductors in pull boxes, panelboards, switchboards, switchgear, motor control centers or motor control enclosures.

E. Identify and color code wire and cable under provisions of Section 26 05 53. Identify each conductor with its circuit number or other designation indicated.

F. Special Techniques--Building Wire in Raceway:
1. Pull conductors into raceway at same time.
2. Install building wire 4 AWG and larger with pulling equipment.
3. A maximum of three branch circuits are to be installed on any one conduit on 3 phase 4 wire system.
4. Install a minimum of twelve inches of slack conductor at each outlet.

G. Special Techniques – SO Cable:
1. Cable connectors shall be steel case liquid tight sized for the cable diameter and shall use strain relief gland fitting to prevent tension on conductor terminals.

H. Special Techniques - Wiring Connections:
1. Clean conductor surfaces before installing lugs and connectors.
2. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
3. Tape uninsulated conductors and connectors with electrical tape equal to the insulation of wire and with all irregular surfaces properly padded with “Scotchfil”, 2nd product or equal putty prior to application of tape. Tape shall be equal to Scotch #33, General Electric #AW-1 or equal
4. Install solderless tool applied pressure connectors and lugs for copper conductor splices and taps, 8 AWG and larger.
5. Install insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
6. Splices in conductors installed below grades are not permitted, unless approved in writing by the University’s Representative.
7. Outdoors or below grade, use wire connectors or compression type with heat shrink style watertight splice covers. Use Scotchcast 3570G resin epoxy to waterproof connections.
8. Install waterproof wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller in outdoor or wet locations.

9. Where oversized cables are used to accommodate voltage drop, whether a single or parallel feeder, provide appropriate reducing adapter and conductors for termination.
10. Secure conductors to circuit breakers, lugs and ground/neutral bus terminations utilizing a torque screwdriver or wrench to the manufacturer's specified torque values.

3.5 WIRE COLOR

A. General

1. Color code all conductors. Wire sizes #6 AWG and smaller shall have integral color-coded insulation. Wire sizes #4 AWG and larger may have black insulation but identified by color coded tape at all junctions, splice, pull or termination points. Tape shall be applied ½ lap to at least 6 inches of conductor. Color code wires as follows:

Conductors	120/209 Volts	277/480 Volts
Phase A	Black	Brown
Phase B	Red	Violet
Phase C	Blue	Yellow
Neutral	White	White or Gray
Ground	Green	Green

B. Branch Circuits: Shared neutral conductors for multiple circuits are not permitted. Provide a separate neutral conductor for each phase conductor.

C. Neutral Conductors: White. When two or more neutrals are located in one conduit, individually identify each with proper circuit number.

D. Branch Circuit Conductors: Install three or four wire home runs with each phase uniquely color coded.

E. Feeder Circuit Conductors: Uniquely color code each phase.

3.6 CONTROL, COMMUNICATION AND SIGNAL CONDUCTORS

A. Install in separate raceway systems from electrical line voltage wiring.

3.7 FIELD QUALITY CONTROL

A. Provide visual and mechanical inspection in accordance with NETA ATS, 7.3.2.A.

B. Subject cables sized #2 AWG and larger, rated 600 volts AC to insulation resistance test per NETA ATS 7.3.2 B.2. Make tests and record insulation resistance with circuits isolated from source and load.

C. Do not megger any cables after connecting to any equipment, unless specifically directed to do so by Architect.

D. Provide written test results and a final report of electrical tests per NETA ATS 5.4 to Architect.

END OF SECTION

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Wire.
   2. Mechanical connectors.
   3. Exothermic connections.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:
   1. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
   2. IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment.

B. International Electrical Testing Association:
   1. ANSI/NETA ATS – 2017 Acceptance Testing Specifications for Electrical Power Equipment and Systems.

C. Part 3, Title 24, - California Electrical Code (CEC).

1.3 SYSTEM DESCRIPTION

A. Grounding systems use the following elements as grounding electrodes:
   1. Existing Metal underground water pipe.
   2. Metal building frame.

B. All panelboards, junction boxes, pull boxes, wireways, device boxes, and equipment enclosures shall be bonded to the separate green equipment grounding conductor.

1.4 SECONDARY GROUNDING SYSTEM

A. The grounding system shall be provided as shown and shall meet the requirements of CEC Article 250.

B. In addition to the major components shown and required by Article 250, the grounding system shall include all fittings, connectors, devices, and material necessary for a complete and useable system.

C. Bond the grounding system to existing building columns.

1.5 QUALITY ASSURANCE

A. Provide grounding materials conforming to requirements of NEC, IEEE 142, and UL labeled.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.

C. Do not deliver items to project before time of installation. Limit shipment of bulk and multiple-use materials to quantities needed for immediate installation.

PART 2 - PRODUCTS

2.1 WIRE

A. Grounding Electrode Conductor: Copper conductor insulated if in conduit or above grade exposed, bare if direct buried.

B. Bonding Conductor: Stranded copper with dual rated THHN/THWN insulation, color identified green. Where continuous color-coded conductors are not commercially available, provide a minimum 4” long color band with green, non-aging, plastic tape in accordance with the CEC.

2.2 MECHANICAL CONNECTORS

A. Description: Bronze connectors, suitable for grounding and bonding applications, in configurations required for installation.

2.3 CONNECTIONS

A. Provide high pressure compression type or exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.
   1. Exothermic welds shall be used for cable to cable and cable and for cable to structural steel surfaces.
   2. Pressure indented copper cable terminal, one hole with one inch galvanized or cadmium plated steel machine bolts and beveled washer each side shall be used for cable-to- ground bar and cable-to-equipment connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify final backfill and compaction has been completed before driving rod electrodes.

3.2 PREPARATION

A. Remove paint, rust, mill oils and surface contaminants at connection points.

3.3 EXISTING WORK

A. Extend existing grounding system using materials and methods as specified.

3.4 GROUNDING ELECTRODE SYSTEM

A. Provide grounding electrode conductor as indicated on the Drawings or sized per CEC Article 250, whichever is greater.

B. Install grounding and bonding conductors concealed from view.

3.5 POWER SYSTEM GROUNDING

A. Provide, unless otherwise indicated, a main building power system ground bus mounted on the wall in new telecom rooms. Connect the following items using CEC sized copper grounding conductors to lugs on the main building ground bus:

1. Bonding conductor to building structural steel.

3.6 EQUIPMENT GROUNDING

A. Equipment Grounding Conductor: Provide a CEC sized insulated copper ground conductor in all 120VAC through 600 VAC feeder and branch circuit distribution conduits and cables.

B. Provide a separate grounding bus at panelboards, switchboards, motor control centers. Connect all metallic enclosed equipment so that with maximum fault current flowing, shall be maintained at not more than 35 volts above ground.

C. Conduit terminating in concentric, eccentric, or oversized knockouts at panelboards, cabinets, gutters, etc. shall have grounding bushings and bonding jumpers installed interconnecting all such conduits.

D. Provide bonding jumpers across expansion and deflection couplings in conduit runs, pipe connections to water meters, dielectric couplings in metallic cold water piping system.

E. Provide internal ground wire in flexible conduit connected at each end via grounding bushing.

F. Provide external ground wire wrapped around flexible conduit and terminate to connectors designed for the purpose.

G. Install continuous grounding using underground cold-water system and building steel as grounding electrode. Where water piping is not available, install artificial station ground by means of driven rods or buried electrodes.

H. Permanently ground entire light and power system in accordance with CEC, including service equipment, distribution panels, lighting panelboards, switch and starter enclosures, motor frames, grounding type receptacles, and other exposed non-current carrying metal parts of electrical equipment.

I. Accomplish grounding of electrical system by using insulated grounding conductor installed with feeders and branch circuit conductors in conduits. Size grounding conductors in accordance with CEC or as indicated on drawings.

J. Install from grounding bus of serving panel to ground bus of served panel, grounding screw of receptacles, lighting fixture housing, light switch outlet boxes or metal enclosures of service equipment.

K. Ground conduits as necessary by means of grounding bushings on terminations at panelboards and switchboards to grounding bus.

L. Permanently attach equipment and grounding conductors prior to energizing equipment.

3.7 SEPARATELY DERIVED ELECTRICAL SYSTEM GROUNDING

A. Ground each separately derived system per requirements in CEC Article 250 as a minimum, unless greater requirements are required elsewhere in the Contract Documents.

B. Transformers: Provide a dual rated four or six-barrel grounding lug with a 5/8"-11 threaded hole. Drill enclosure with 11/16" bit and attach lug to enclosure utilizing a torque bolt and a dragon tooth transition washer or equal. Connect the following when present:

1. Building steel.

3.8 FIELD QUALITY CONTROL

A. Provide visual and mechanical inspection in accordance with NETA ATS, 7.13.A.

END OF SECTION

SECTION 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Conduit and cable tray supports.
2. Formed steel channel.
3. Spring steel clips.
4. Sleeves.
5. Mechanical sleeve seals.
6. Firestopping relating to electrical work.
7. Floor and wall mounted equipment base and support.

1.2 REFERENCES

A. ASTM International:
1. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
2. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
3. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
4. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

B. Part 3, Title 24, - California Electrical Code (CEC).]

C. Underwriters Laboratories Inc.:
1. UL 1479 - Fire Tests of Through-Penetration Firestops.
2. UL - Fire Resistance Directory.

1.3 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.

1.4 SYSTEM DESCRIPTION

A. Firestopping Materials: UL 1479, to achieve fire ratings in accordance with UL Design Numbers noted on Drawings.

1.5 PERFORMANCE REQUIREMENTS

A. Penetrations: Provide through-penetration firestop systems that are installed to resist the spread of fire, passage of smoke and other hot gases according to requirements indicated, to restore the original fire-resistance rating of assembly penetrated.
1. Install complete through penetration firestop systems that have been tested and are listed

by recognized testing agencies per ASTM E 814 or UL 1479 fire tests in a configuration that is representative of site conditions.

2. F-Rated Systems: Install through-penetration firestop systems with F-ratings indicated, as determined per ASTM E 814 or UL 1479, but not less than the fire resistance rating of the assembly being penetrated.
3. T-Rated Systems: Install through-penetration firestop systems with T-ratings indicated, as well as F-ratings, as determined per ASTM E 814 or UL 1479, where required by the Building Code.

B. Support systems shall be adequate for weight of equipment and raceways, including wiring which they carry.

1.6 SUBMITTALS

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

B. Design Data: Indicate load carrying capacity of hangers and supports.

C. Manufacturer's Installation Instructions:
   1. Hangers and Supports: Submit special procedures and assembly of components.
   2. Firestopping: Submit preparation and installation instructions.

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

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

1.7 SEISMIC DETAILS AND CALCULATIONS

A. Submit details and calculations for support and anchors that are not specifically detailed on the Drawings where required by California Building Standards Code, California Code of Regulations, Title 24. Pre-approved systems may be used as noted below only if the pre-approval is current and accepted by the local agency having jurisdiction.

1.8 QUALITY ASSURANCE

A. Through Penetration Firestopping of Fire Rated Assemblies: UL 1479 with 0.10-inch water gage minimum positive pressure differential to achieve fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
   1. Wall Penetrations: Fire F-Ratings as indicated on Drawings, but not less than 1-hour.
   2. Floor Penetrations: Fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
      a. Floor Penetrations Within Wall Cavities: T-Rating is not required.

B. Through Penetration Firestopping of Non-Fire Rated Floor and Roof Assemblies: Materials to resist free passage of flame and products of combustion.
   1. Noncombustible Penetrating Items: Noncombustible materials for penetrating items connecting maximum of three stories.
   2. Penetrating Items: Materials approved by authorities having jurisdiction for penetrating

items connecting maximum of two stories.

1.9 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years experience.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Do not apply firestopping materials when temperature of substrate material and ambient air is below 60 degrees F.

B. Maintain this minimum temperature before, during, and for minimum 3 days after installation of firestopping materials.

PART 2 - PRODUCTS

2.1 CONDUIT SUPPORTS

A. Hanger Rods: Threaded high tensile strength galvanized carbon steel with free running threads.

B. Beam Clamps: Steel or Malleable Iron, with tapered hole in base and back to accept either bolt or hanger rod. Set screw: hardened steel.

C. Conduit clamps for trapeze hangers: Galvanized steel, notched to fit trapeze with single bolt to tighten.

D. Conduit clamps - general purpose: One-hole malleable iron for surface mounted conduits.

E. Cable Ties: High strength nylon temperature rated to 185 degrees F. Self locking.

2.2 FORMED STEEL CHANNEL

A. Product Description: 1 5/8 inches square Galvanized 12 gage thick steel. With holes 1-1/2 inches on center.

2.3 SPRING STEEL CLIPS

A. Spring steel conduit hanger to threaded rod.

2.4 SLEEVES

A. Sleeves for Through Non-fire Rated Floors: 18 gage thick galvanized steel.

B. Sleeves for Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage thick galvanized steel.

C. Sleeves for Through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed.

D. Fire-stopping Insulation: Glass fiber type, non-combustible.

2.5 MECHANICAL SLEEVE SEALS

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

2.6 FIRESTOPPING

A. Product Description: Different types of products by multiple manufacturers are acceptable as required to meet specified system description and performance requirements; provide only one type for each similar application.
   1. Intumescent Firestopping: Intumescent putty compound which expands on exposure to surface heat gain.

2.7 FIRESTOPPING ACCESSORIES

A. Primer: Type recommended by firestopping manufacturer for specific substrate surfaces and suitable for required fire ratings.

B. Installation Accessories: Provide clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.

C. General:
   1. Furnish UL listed products.
   2. Select products with rating not less than rating of wall or floor being penetrated.

D. Non-Rated Surfaces:
   1. Stamped steel, chrome plated, hinged, split ring escutcheons or floor plates or ceiling plates for covering openings in occupied areas where conduit is exposed.
   2. For exterior wall openings below grade, furnish modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill annular space between conduit and cored opening or water-stop type wall sleeve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify openings are ready to receive sleeves.

B. Verify openings are ready to receive firestopping.

3.2 PREPARATION

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

B. Remove incompatible materials affecting bond.

C. Install damming materials to arrest liquid material leakage.

D. Obtain permission from Architect/Engineer before using powder-actuated anchors.

E. Do not drill or cut structural members.

3.3 INSTALLATION - HANGERS AND SUPPORTS

A. Anchors and Fasteners:
   1. Concrete Structural Elements: Provide expansion anchors.
   2. Steel Structural Elements: Provide beam clamps.
   3. Concrete Surfaces: Provide expansion anchors.
   4. Hollow Masonry, Plaster, and Gypsum Board Partitions: Provide structural backing plate.
   5. Solid Masonry Walls: Provide expansion anchors.
   6. Sheet Metal: Provide sheet metal screws.
   7. Wood Elements: Provide wood screws.

B. Install conduit and raceway support and spacing in accordance with the California Electrical Code.

C. Install all support devices according to manufacturer’s guidelines and recommendations.

D. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.

E. Do not drill through structural framing members.

F. Do not support equipment or fixtures from the roof deck. Provide necessary framing and joist hangers to span between structural members to locate hangers properly.

G. Install multiple conduits runs on common hangers.

H. Supports:
   1. Fabricate supports from structural steel or formed steel channel. Install hexagon head bolts to present neat appearance with adequate strength and rigidity. Install spring lock washers under nuts.
   2. Install surface mounted cabinets and panelboards with minimum of four anchors.
   3. In wet and damp locations install steel channel supports to stand cabinets and panelboards 1 inch off wall.
   4. Support vertical conduit at every floor.
   5. Clip type hangers may be used in concealed areas on individual conduit runs.
   6. Group mounted, exposed, or concealed raceways shall be supported by trapeze hangers constructed of formed steel channels and treaded rods.

3.4 INSTALLATION - FIRESTOPPING

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

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

C. Fire Rated Surface:
   1. Seal opening at floor, wall, partition, ceiling, and roof as follows:
      a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
      b. Pack void with backing material.
      c. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.

D. Non-Rated Surfaces:
   1. Seal opening through non-fire rated wall, partition floor, ceiling, and roof opening as follows:
      a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
      b. Install type of firestopping material recommended by manufacturer.
   2. Install escutcheons where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces include rooms with finished ceilings and where penetration occurs below finished ceiling.
   3. Exterior wall openings below grade: Assemble rubber links of mechanical seal to size of conduit and tighten in place, in accordance with manufacturer's instructions.
   4. Interior partitions: Seal pipe penetrations at telecommunication rooms. Apply sealant to both sides of penetration to completely fill annular space between sleeve and conduit.

3.5 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment.

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

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

3.6 INSTALLATION - SLEEVES

A. Exterior watertight entries: Seal with adjustable interlocking rubber links.

B. Conduit penetrations not required to be watertight: Sleeve and fill with silicon foam.

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

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

E. Extend sleeves through floors 1 inch above finished floor level. Caulk sleeves.

F. Where conduit or raceway penetrates floor, ceiling, or wall, close off space between conduit or

raceway and adjacent work with fire stopping insulation and caulk.

G. Install chrome plated steel escutcheons at finished surfaces where penetrations occur below finished ceilings.

3.7 FIELD QUALITY CONTROL

A. Inspect installed firestopping for compliance with specifications.

3.8 CLEANING

A. Clean adjacent surfaces of firestopping materials.

3.9 PROTECTION OF FINISHED WORK

A. Protect adjacent surfaces from damage by material installation.

END OF SECTION

SECTION 260533

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes conduit and tubing, surface raceways, wireways, outlet boxes, pull and junction boxes.

B. Related Sections:
1. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
2. Section 26 05 29 - Hangers and Supports for Electrical Systems.
3. Section 26 05 53 - Identification for Electrical Systems.
4. Section 26 27 16 - Electrical Cabinets and Enclosures.
5. Section 26 27 26 - Wiring Devices.

1.2 REFERENCES

A. American National Standards Institute:
1. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
2. ANSI C80.3 - Specification for Electrical Metallic Tubing, Zinc Coated.

B. National Electrical Manufacturers Association:
1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
2. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
3. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
4. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.
5. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
6. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
7. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

C. Part 3, Title 24, - California Electrical Code (CEC).

1.3 SYSTEM DESCRIPTION

A. Raceway and boxes located as indicated on Drawings, and at other locations required for splices, taps, wire pulling, equipment connections, and compliance with regulatory requirements. Raceway and boxes are shown in approximate locations unless dimensioned. Provide raceway to complete wiring system.

1.4 DESIGN REQUIREMENTS

A. Minimum Raceway Size:
1. 3/4 inch.
2. 1 inch outside foundation line.

1.5 SUBMITTALS

A. Product Data: Submit for the following:
   1. Metallic conduit.
   2. Electrical metallic tubing.
   3. Flexible metal conduit.
   4. Liquid tight flexible metal conduit.
   5. Nonmetallic conduit.
   6. Raceway fittings.
   7. Conduit bodies.
   8. Surface raceway.
   9. Wireway.
   10. Pull and junction boxes.

B. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

C. Provide Seismic Shop Drawings from a structural engineer licensed in the state of California for any conduit support systems containing conduits 2.5” or larger in trade size or assemblies weighing over 10 lbs. per linear foot which are suspended further than 12” from the point attachment to the building structure to the top of the conduit or trapeze support systems.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents:
   1. Record actual routing of conduits larger than 2 inches.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

1.8 COORDINATION

A. Coordinate mounting heights, orientation and locations of outlets mounted above counters, benches, and backsplashes.

B. Coordinate Work of this Division and Work of other Divisions in advance of installation. Provide additional Work to overcome tight conditions at no increase in Contract Sum.

C. Coordinate installation of outlet boxes for equipment specified in other divisions.

PART 2 - PRODUCTS

2.1 METAL CONDUIT

A. Rigid Steel Conduit: ANSI C80.1.

B. Intermediate Metal Conduit (IMC): Rigid steel.

C. Fittings: NEMA FB 1. Fittings shall be steel with threaded fittings. Use insulated metallic bushings with lug where ground connections are required. Use plastic bushing for non-bonding applications.

D. Conduit Bodies: Bodies connected to rigid steel or intermediate conduit shall be the cast iron. Provide matching gasketed stainless steel cover with at least two corrosion resistant screws. Die cast aluminum products are not permitted.

2.2 PVC COATED METAL CONDUIT

A. Product Description: NEMA RN 1; rigid steel conduit with external PVC coating, 40 mil thick.

B. Fittings and Conduit Bodies: NEMA FB 1; steel fittings with external PVC coating to match conduit.

2.3 FLEXIBLE METAL CONDUIT

A. Product Description: Interlocked steel construction.

B. Fittings: NEMA FB 1; Fittings shall be steel insulated throat type rated as suitable for system ground continuity.

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Product Description: Interlocked steel construction with PVC jacket. Minimum size shall be ¾".

B. Fittings: NEMA FB 1; fittings shall be liquid tight with watertight connectors when installed in damp or wet locations.

C. Connectors for liquid tight flexible conduit shall be screw-in ground cone type.

2.5 ELECTRICAL METALLIC TUBING (EMT)

A. Product Description: ANSI C80.3; galvanized tubing.

B. Fittings: NEMA FB 1; steel compression concrete tight couplings and connectors. Fittings shall meet same requirements for finish and material as EMT conduit. Box connectors shall have nylon insulated throat. Set screw type couplings are not permitted.

C. Fittings shall be assembled with anti-corrosion, conductive anti-seize compound at joints made tight to exclude water.

D. Conduit Bodies: Bodies shall be the cast iron. Provide matching gasketed stainless steel cover with at least two corrosion resistant screws. Die cast aluminum products are not permitted.

2.6 NONMETALLIC CONDUIT

A. Product Description: NEMA TC 2; Schedule 40 or 80 PVC.

B. Fittings: NEMA TC 3.

C. Non-metallic conduit fittings shall be of the same material as the conduit furnished and be the product of the same manufacturer.

D. PVC 90-degree bends shall not be used. Wrapped rigid conduit will be used in its place. Double lap of Calpico 10 mil or approved equal.

2.7 WEATHERPROOF CABLE TERMINATERS

A. Product Description: Dust tight and liquid tight with sealing ring and insulated throat.

B. Bushing shall be OZ/Gedney type KR or equal.

2.8 EXPANSION AND DEFLECTION FITTINGS

A. OZ/Gedney type DX or equal.

2.9 SURFACE METAL RACEWAY

A. Manufacturers:
   1. The Wiremold Co. Series 2000, 3000 4000, &6000.
   2. Approved equal.

B. Product Description: Sheet metal channel with fitted cover, suitable for use as surface metal raceway.

C. Wireway systems smaller than Wiremold series 700, or equal are notpermitted.

D. Finish: Gray enamel.

E. Fittings, Boxes, and Extension Rings: Furnish manufacturer's standard accessories; match finish on raceway.

2.10 WIREWAY

A. Product Description: Steel, general purpose or Raintight type wireway.

B. Finish: Rust inhibiting primer coating with gray enamel finish.

C. Wireway systems shall have dividers between line voltage and low voltage systems.

2.11 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel.
   1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; furnish 1/2-inch male fixture studs where required.
   2. Boxes for shall be 1-1/2 inch deep by 4-inch square minimum.
   3. Concrete Ceiling Boxes: Concrete type.

B. Nonmetallic Outlet Boxes: NEMA OS 2.

C. Cast Boxes: NEMA FB 1, Type FD, cast ferroalloy. Furnish gasketed cover by box manufacturer. Furnish threaded hubs.

D. Wall Plates for Finished Areas: As specified in Section 26 27 26.

E. Wall Plates for Unfinished Areas: Furnish gasketed cover.

2.12 PULL, SPLICE AND JUNCTION BOXES

A. Indoor general-purpose boxes shall be a NEMA 1 enclosure, constructed of code gauge galvanized steel. The boxes shall be constructed from a single piece of steel with folded and welded corners. Boxes shall have hinged covers or flat removable, galvanized sheet metal covers held in place with binder head sheet metal screws.

B. Outdoor boxes surface mounted above ground in wet locations shall be cast iron with a plain cast iron cover. Covers shall be neoprene gasketed and shall be NEMA 4 watertight construction. The cover shall be held in place by stainless steel screws.

C. Size boxes based on code and working space requirements related to the number and size of conduits and wire entering the box.

D. For recessed boxes, use an outside flanged recessed cover. For outdoor boxes mounted on exterior surfaces, use an un-flanged box with weather seals.

E. Conduit openings shall be bossed, drilled, and tapped in outdoor boxes.

F. Standard size metal boxes stamped from galvanized steel shall be used for indoor above ground general purpose where size and capacity are acceptable by code.

G. Boxes shall be of the depth required for wiring capacity.

H. Above ground outdoor boxes shall be cast iron with threaded hubs for vapor tight and wet locations where indicated.

I. Boxes for hazardous (classified) locations shall be approved for the classification and use.

J. Provide boxes with a blank cover.

K. Hinged Enclosures: As specified in Section 26 27 16.

2.13 UNDERGROUND BOXES

A. Underground boxes 24-inches square or larger shall be high density reinforced concrete with end and side knockouts. All such boxes shall be back filled around the outside with concrete. Each shall be equipped with the following reinforced concrete accessories:

1. Extensions as required
2. Box floor
3. Lid with hold down bolts and labeled with usage. (Steel checker plate with hold down bolts in traffic areas.)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify outlet locations and routing and termination locations of raceway prior to rough-in.

3.2 EXISTING WORK

A. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces.

B. Remove concealed abandoned raceway to its source.

C. Disconnect abandoned outlets and remove devices. Remove abandoned outlets when raceway is abandoned and removed. Install blank cover for abandoned outlets not removed.

D. Maintain access to existing boxes and other installations remaining active and requiring access. Modify installation or provide access panel.

E. Extend existing raceway and box installations using materials and methods as specified.

F. Clean and repair existing raceway and boxes to remain or to be reinstalled.

3.3 INSTALLATION

A. Contractor shall have reviewed and approved Seismic Shop Drawings prior to installation of raceways which require seismic support.

B. Ground and bond raceway and boxes in accordance with Section 26 05 26.

C. Fasten raceway and box supports to structure and finishes in accordance with Section 26 05 29.

D. Identify raceway and boxes in accordance with Section 26 05 53.

E. Arrange raceway and boxes to maintain headroom and present neat appearance.

F. Maintain minimum 12” clearance from top of suspended ceiling to bottom of conduits where possible.

G. Electrical wiring, conduits and boxes may not be installed within 1 ½” of metal deck roofs.

3.4 INSTALLATION - RACEWAY

A. Provide completely separate raceways for the life safety, critical, equipment, and normal branch power systems in accordance with the CEC.

B. Conceal all conduits, except in unfinished spaces such as equipment rooms or were indicated by symbol on the drawings or as approved by the University's Representative. Run concealed in areas having finished ceilings and furred walls.

C. Support raceway using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

D. Group related raceway; support using conduit rack. Construct rack using steel channel specified in Section 26 05 29; provide space on each for 25 percent additional raceways.

E. Do not support raceway with wire or perforated pipe straps. Remove wire used for temporary supports.

F. Do not attach raceway to ceiling support wires or other piping systems.

G. Construct wireway supports from steel channel specified in Section 26 05 29.

H. Route exposed raceway parallel and perpendicular to walls.

I. Do not route flexible conduit through rated or non-rated walls.

J. Route raceway installed above accessible ceilings parallel and perpendicular to walls.

K. Maintain clearance between raceway and piping for maintenance purposes.

L. Maintain 2-inch clearance between raceway running perpendicular to piping with temperatures exceeding 104 degrees F.

M. Maintain 12-inch clearance between raceway and surfaces with temperatures exceeding 104 degrees F.

N. Cut conduit square using saw or pipe cutter; de-burr cut ends.

O. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for minimum 20 minutes.

P. Install conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.

Q. Provide pull boxes or junction boxes in conduit runs over 90' long or when more than 4 quarter bends occur in a conduit run.

R. Install conduit bodies to make sharp changes in direction, as around beams.

S. Avoid moisture traps; install junction box with drain fitting at low points in conduit system.

T. Install fittings to accommodate expansion and deflection were raceway crosses seismic, control or expansion joints.

U. Fittings for IMC or rigid steel conduits shall be assembled with anti-corrosion, conductive anti-seize compound at joints made to exclude water.

V. Install suitable pull string or cord in each empty raceway except sleeves and nipples.

W. Surface Raceway: Install flat-head screws, clips, and straps to fasten raceway channel to surfaces; mount plumb and level. Install insulating bushings and inserts at connections to outlets and corner fittings.

X. Close ends and unused openings in boxes and wireway.

3.5 USES PERMITTED

A. Galvanized rigid conduit or IMC shall be used as follows:
   1. For primary and secondary service (except when installed below the ground floor slab and above the building mat slab) and for secondary unit substations, switchboard, motor control center, dry-type transformer, and panelboard feeders.
   2. Buried in or in contact with earth to be half-lapped with omic pipe wrapping tape with sealant applied to all joints.
   3. In poured concrete walls, floor, and roof construction, provided a minimum of 2" of cover is maintained.
   4. In all walls up to the first outlet box where fed from rigid conduit in damp locations or locations exposed to the weather.
   5. In exposed locations below 8 feet above the floor, including all mechanical rooms.
   6. All elbows for underground plastic conduit.
   7. All conduits for interior wiring systems whose voltage is above 600 volts.
   8. All conduits entering refrigerated spaces.
   9. Elsewhere where indicated on the drawings.
   10. For emergency branch feeders and circuits installed outside of building.

B. Electrical metallic tubing (EMT) shall be used as follows:
   1. Concealed in stud partitions and hollow masonry walls.
   2. For connections from junction box to lighting fixtures except in accessible ceilings.
   3. In suspended or accessible ceilings above 8 feet.
   4. Exposed in dry locations above 8 feet where not subjected to mechanical damage.
   5. In furred ceiling spaces.

C. Rigid non-metallic conduit shall be used as follows:
   1. For the branch circuit wiring for exterior lighting pole bases and bollards (horizontal runs only).
   2. All elbows, both vertical and horizontal, shall be GRC.
   3. Any non-metallic PVC conduit used for emergency power systems shall be schedule 80 PVC.
   4. The communications conduit shall be schedule 40 PVC.

D. Flexible steel conduit shall be used as follows:
   1. Recessed lighting fixtures. (6ft max)
   2. Motor connections.
   3. Connection between fan plenum and structure.
   4. At expansion joints.
   5. At transformers and other equipment which produces vibration.
   6. At damp and wet locations or where exposed to weather, flexible steel conduit shall be liquid tight type.
   7. Up to 20 feet of length is permitted between receptacles and light fixtures within the same single room.
   8. Tite-bite type connectors shall be used.
   9. All flexible steel conduit shall be used with code sized ground wire installed.
   10. All homeruns shall be in conduit, do not use flexible conduits for any homeruns routed to panels.

E. All other conduit, unless excluded herein, not permitted in accordance with the California Electrical Code, or otherwise indicated on the drawings, shall be electrical metallic tubing (EMT).

F. Conduit types shall not be mixed indiscriminately with other types in the same run, unless specified herein or required by the CEC.

G. Use flexible conduit for connections to motors, dry type transformers, electrical duct heaters, unit heaters, and flush mounted lighting fixtures. Conduit must be secured.

1. Flexible conduit used for connection of motor, dry type transformers, electric duct heaters, and unit heaters, shall not exceed 18" in length.
2. Flexible conduit from outlet box to flush mounted lighting fixture shall not exceed 6 feet in length.
3. Maintain ground continuity through flexible conduit with green equipment grounding conductor; do not use flexible conduit for ground continuity.
4. Liquid tight conduit shall be used to connect equipment in mechanical equipment rooms and exterior installations, and for final connections to all equipment containing water or other liquid service.

H. No conduit requiring cutting of cross-webs of concrete masonry units is permitted. Conduit shall be threaded through cells or concrete masonry units lowered around conduit. Neither horizontal joint reinforcement nor bond beam reinforcement shall be cut for conduit installation.

I. Where hazardous locations, as classified by the CEC, exist, all conduits and fittings and the installation of these materials shall comply with Article 500.

J. Direct Burial PVC Conduit

1. Minimum size 1.0”.
2. Unless otherwise indicated install top of conduits 24" minimum below finished grade. All conduits not under building slabs or parking lots shall be encased in a minimum of 3" concrete. All concrete for primary conduit shall contain a red pigment dye to make it readily noticeable. Provide 10% red oxide per cubic yard of material.
3. Install top of conduits 30" minimum below grade, below roads and any other paved surfaces.
4. Place a 4" wide, bright yellow, non-biodegradable plastic tape 12" above all underground conduit outside of building foundation.
5. Where transition is made from below grade PVC installation to a metallic conduit system above grade or slab, make transition with rigid galvanized elbow and extend through slab or above grade with galvanized rigid steel conduit. For corrosion protection, where the elbow penetrates surface, wrap with vinyl all-weather electrical tape for 6" above and below concrete surface.
6. For all underground runs of two or more conduits, separators or spacing blocks made of plastic or other suitable nonmetallic, non-decaying material shall be placed on not greater than four-foot centers. They shall be of the interlocking type both horizontally and vertically. Ducts shall be anchored to prevent movement during placement of concrete.

K. Raceway Installations Within Concrete

1. Conduits shall not be installed within shear walls unless specifically indicated on the drawings. Conduits shall not be run directly below and parallel with load bearing walls.

2. Conduit stub-up penetrations through slabs shall be installed with the top of a threaded conduit coupling flush with the finished slab.
3. Protect all conduits entering and leaving concrete floor slabs from physical damage during construction.

3.6 INSTALLATION - BOXES

A. Boxes for Concealed Conduits:
   1. Flush mounted.
   2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.

B. Install wall mounted boxes at elevations to accommodate mounting heights as indicated on Drawings.

C. Adjust box location up to 10 feet prior to rough-in to accommodate intended purpose.

D. Orient boxes to accommodate wiring devices oriented as specified in Section 26 27 26.

E. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.

F. In Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 24 inches from ceiling access panel or from removable recessed luminaire.

G. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

H. Provide acoustical rated moldable putty pads for all boxes located in acoustic rated walls.

I. Provide fire rated moldable putty pads for all boxes located in fire rated walls.

J. Secure flush mounting box to interior wall and partition studs with screws, not nails. Use box support bracket with far side support leg for outlets installed on wall studs.

K. Install stamped steel bridges to fasten flush mounting outlet box between studs.

L. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

M. Install adjustable steel channel fasteners for hung ceiling outlet box.

N. Do not fasten boxes to ceiling support wires or other piping systems.

O. Support boxes independently of conduit.

P. Install gang box where more than one device is mounted together. Do not use sectional box.

Q. Install gang box with plaster ring for single device outlets.

R. Outlet boxes located below eight feet in exposed interior dry locations shall be one piece drawn steel or cast type.

3.7 INSTALLATION CONCRETE COMPOSITE BOXES

A. Install boxes direct buried in earth or concrete flush with surface, square with surrounding structures.

B. Provide hold down bolts for all covers.

C. Provide minimum 12” depth of crushed rock or pea gravel below boxes for drainage. Ground bond steel cover plate with insulated green grounding conductor.

D. Install suitable caps to protect installed conduit against entrance of dirt and moisture.

3.8 INTERFACE WITH OTHER PRODUCTS

A. Install conduit to preserve fire resistance rating of partitions and other elements.

B. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate location with roofing installation specified in other Sections.

C. Locate outlet boxes to allow luminaires positioned as indicated on Drawings.

D. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.

3.9 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closures in unused openings in boxes.

3.10 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

B. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Nameplates.
   2. Wire markers.
   3. Junction box identification.
   4. Inscribed cover plates.
   5. Underground Warning Tape.

1.2 QUALITY ASSURANCE

A. Provide material supplied by a manufacturer producing identification systems

B. Comply with OSHA, NFPA or local jurisdiction identification requirements for electrical systems.

1.3 ENVIRONMENTAL REQUIREMENTS

A. Install labels or nameplates only when ambient temperature and humidity conditions for adhesive are within range recommended by manufacturer.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Provide engraved plastic-laminate sign on each major unit of electrical equipment in building, including:
   1. Electrical cabinets, panels, switchboards, and enclosures.
   2. Transformers.

B. Each individually mounted circuit breaker, and each breaker in the switchboards, secondary unit substations, and distribution panels shall have a nameplate.

C. Nameplates shall have ½” high text lettering on 1-1/2” high nameplate (with 2” high used for nameplates with multiline text).

D. Nameplates shall be color coded to match existing electrical system.

E. Equipment identification is to indicate the following:
   1. Equipment ID abbreviation.
   2. Voltage, phase, and wires.
   3. Power source description or system.
   4. Power source origination.

5. Example: Panel SLGHA1; 480/277V, 3 Ø, 4 W.
6. Life Safety System; Fed by EM1

F. Minimum nameplate thickness: 1/16 inch for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Furnish with pre-punched holes for mechanical fasteners.

G. All electrical devices and switches shall have engraved device covers, 1/8" high letters. Include panel name and circuit number.

2.2 BOX IDENTIFICATION:

A. After completion, using an indelible wide tip marker, indicate on the cover of each junction and pull box the designation of the circuits contained therein, i.e., A-1, 3, 5.

B. After box installation and wire termination completion all junction box and pull box covers shall be field marked/painted as follows:
1. Normal branch power circuits "Green"
2. Emergency branch power circuits "Red"

2.3 WIRE MARKERS

A. Description: Self-adhering, pre-printed or machine printable, self-laminating vinyl wrap around strips. Inscribe blank markers using the printer recommended by the manufacturer for this purpose.

B. All conductors shall be marked and identified. Include voltage, phase, and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present.

C. Legend:
1. Power and Lighting Circuits: Branch circuit or feeder number as indicated on Drawings.
2. Control Circuits: Control wire number as indicated on shop drawings.

2.4 CONDUCTOR PHASE MARKERS

A. Colored vinyl plastic electrical tape, 3/4 inch wide, for identification of phase conductors.

2.5 UNDERGROUND WARNING TAPE

A. Description: 6-inch-wide plastic tape, detectable type, colored yellow or red with suitable warning legend describing buried electrical lines.

2.6 LOCKOUT DEVICES

A. Lockout Hasps:
1. Anodized aluminum hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EXISTING WORK

A. Install identification on existing equipment to remain in accordance with this section.

B. Install identification on unmarked existing equipment.

C. Replace lost nameplates, labels, and markers.

D. Provide updated, type written, panelboard schedules for all branch circuit work completed as part of renovation and/or new construction projects. Schedules shall include the load description and the room number or area installed.

3.3 INSTALLATION

A. Install identifying devices after completion of painting.

B. Nameplate Installation:
   1. Install nameplate parallel to equipment lines.
   2. Install nameplates for each control panel and major control components located outside panel with corrosive-resistant mechanical fasteners.
   3. Fasteners for equipment or device tag identification shall be self-tapping stainless-steel screws, except contact-type permanent adhesive where screws cannot be used or should not penetrate the substrate material of the equipment.

C. Nameplates for signal systems equipment and devices are to be black except as follows:
   1. Fire alarm and life safety - White with red letters

D. Inscribed Electrical Device Cover plate:
   1. General: Lettering type shall be Helvetica, 12 point or 1/8" high. Color of characters shall be black. Locate the top of the inscription 1/2" below the top edge of the cover plate. Inscription shall be centered and square with cover plate.
   2. Provide inscribed cover plates for devices as outlined below:
      a. Receptacles and switches.
      b. Outlets in surface raceways.
      c. Multi-ganged (four or more) switch arrangement.
      d. Special purpose switches, i.e., projection screens, shades, exhaust fans, etc.

E. Wire Marker Installation:
   1. Install wire marker for each conductor at panelboard gutters, pull boxes, outlet and junction boxes, and each load connection.
   2. Provide colored plastic phase tape in half-lapped turns for a distance of 3 inches from terminal points and in boxes where splices or taps are made.

F. Box Identification:
   1. After completion, using an indelible wide tip marker, indicate on the cover of each junction and pull box the designation of the circuits contained therein, i.e., A-1, 3, 5.
   2. All junction and pull boxes for wiring systems above 600V shall be identified with high voltage warning labels installed every 20 linear feet in accordance with OSHA standards.

All boxes shall also be painted red.

G. After box installation and wire termination completion all junction box and pull box covers shall be field marked/painted as follows:
   1. Normal branch power circuits "Green"
   2. Emergency branch power circuits "Red"

H. Conduit and Raceway Identification:
   1. Where electrical conduit is exposed in spaces with exposed mechanical piping which is identified by color-coded method, apply color-coded identification on electrical conduit in manner similar to piping identification. Except as otherwise indicated, use white as coded color for conduit.

3.4 UNDERGROUND WARNING TAPE:

A. Install underground warning tape along length of each underground conduit, raceway, or cable 6 to 8 inches below finished grade, directly above buried conduit, raceway, or cable.

3.5 BRASS TAGS:

A. Provide brass tags for all feeder cables in underground vaults and pull boxes.

B. Provide brass tags for empty conduits in underground vaults, pull boxes and stubs.

3.6 WARNING, CAUTION, AND INSTRUCTION SIGNS

A. Provide warning, caution or instruction signs where required by OSHA, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems.
   1. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system of equipment operation
   2. Provide polyester film self-adhesive signs of indoor/outdoor equipment and door warning. Use rigid polyethylene non-adhesive signs where adhesives will not work; for example, installing on a metal fence. Provide sign color and marking that meets OSHA regulations. For example, DANGER (red background with white letters), HIGH VOLTAGE (white with black letters.
      a. Use 2 by 4-inch signs for small equipment or enclosure doors.
      b. Use 7 by 10 inch or 10 by 14-inch signs for large equipment or enclosure doors.

B. Emergency Operating Signs: Install engraved laminate signs with white letters on red background with minimum 3/8-inch-high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

3.7 FIRESTOPPING

A. Firestopping shall be labeled at each location where installed, on each side of the penetrated fire barrier, and within 12 in. of the firestopping material.

END OF SECTION

SECTION 260573

SHORT-CIRCUIT/COORDINATION STUDY AND ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes short circuit and protective device coordination studies encompassing portions of electrical distribution system from normal power source or sources up to and including breakers in service entrance switchboard, main breaker in sub-distribution panels, and main breaker in each panelboard.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

C. Related Sections:
   1. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
   2. Section 26 22 00 - Low-Voltage Transformers.
   3. Section 26 24 16 - Panelboards.
   4. Section 26 28 19 - Enclosed Switches.
   5. Section 26 28 23 - Enclosed Circuit Breakers.

1.2 REFERENCES

A. International Electrical Testing Association:
   1. ANSI/NETA ATS – 2017 Acceptance Testing Specifications for Electrical Power Equipment and Systems.

B. Institute of Electrical and Electronics Engineers:
   1. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

C. Part 3, Title 24, - California Electrical Code (CEC).

D. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

E. NFPA 70E – Standard for Electrical Safety in the Workplace

1.3 SHORT CIRCUIT AND PROTECTIVE DEVICE COORDINATION STUDY

A. Complete Short Circuit, Protective Device Coordination Study and Arc Flash Hazard Analysis to meet requirements of NFPA 70.

B. Report shall demonstrate that all emergency system overcurrent devices are selectively coordinated to restrict outages to the circuit or equipment affected. This shall be accomplished by providing overcurrent protective devices and their ratings or settings, utilizing the 0.10 second

level of the overcurrent protective device from the time-current curve as the basis for the lower limit of the calculation method.

C. Report Preparation:
   1. Prepare study prior to ordering distribution equipment to verify equipment ratings required.
   2. Perform study with aid of computer software program.
   3. Obtain actual settings for equipment incorporated into Work.
   4. Calculate short circuit interrupting and, when applicable, momentary duties for assumed 3-phase bolted fault short circuit current and phase to ground fault short circuit current at each of the following:
      a. Low-voltage switchgear.
      b. Switchboards.
      c. Distribution panelboards.
      d. Branch circuit panelboards.
      e. Each other significant equipment location throughout system.

D. Report Contents:
   1. Include the following:
      a. Calculation methods and assumptions.
      b. Base per unit value selected.
      c. One-line diagram.
      d. Source impedance data including power company system available power and characteristics.
      e. Typical calculations.
         1) Fault impedance.
         2) X to R ratios.
         3) Asymmetry factors.
         4) Motor fault contribution.
         5) Short circuit kVA.
         6) Symmetrical and asymmetrical phase-to-phase and phase-to-ground fault currents.
         7) Tabulations of calculation quantities and results.
      f. One-line diagram revised by adding actual instantaneous short circuits available.
      g. Incident energy and flash protection boundary calculations.
      h. State conclusions and recommendations.
   2. Prepare time-current device coordination curves graphically indicating coordination proposed for system, centered on conventional, full-size, log-log forms.
   3. Prepare with each time-curve sheet complete title and one-line diagram with legend identifying specific portion of system covered by that particular curve sheet.
   4. Prepare detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.
   5. Plot device characteristic curves at point reflecting maximum symmetrical fault current to which device is exposed. Include on curve sheets the following:
      a. Low voltage equipment circuit breaker trip device characteristics.

b. Low voltage equipment fuse characteristics.
c. Cable damage point characteristics.
d. Pertinent transformer characteristics including:
    1) Transformer full load current.
    2) Transformer magnetizing inrush.
    3) ANSI transformers withstand parameters.
    4) Significant symmetrical fault current.
e. Pertinent motor characteristics.
f. Generator characteristics including:
    1) Phase and ground coordination of generator protective devices.
    2) Decrement curve and damage curve.
    3) Operating characteristic of protective devices.
    4) Actual impedance value.
    5) Time constants.
    6) Current boost data.
    7) Do not use typical values for generator.
g. Transfer switch characteristics.
h. Other system loads protective device characteristics.

1.4 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2018, Annex D.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, equipment disconnects, busway and splitters) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all MV, 575v, & 480v locations and significant locations in 240 volt and 208-volt systems.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

F. For arc flash calculations, the worst-case scenario is not always described by the greatest magnitude of fault current. The Arc Flash Analysis shall use the maximum and minimum available fault current available at the utility to consider several scenarios and providing a worst-case scenario for each system location. The arc flash analysis will, therefore, include calculations for maximum and minimum contributions of fault current magnitude.

G. Motors receiving power via variable frequency drives are not considered to have fault contributions. All motors less than 50hp shall be lumped into a single motor model. All motors are to be considered running (contributing).

H. Arc flash computation shall include both line and load side of main breaker calculations, where necessary. The worst-case scenario incident energy value (Cal/cm2) shall be applied to the Arc Flash label.

I. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-20018 section B.1.2.

1.5 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Qualifications Data: Submit the following for review prior to starting study.
   1. Submit qualifications and background of firm.
   2. Submit qualifications of Professional Engineer performing study.

C. Software: Submit for review information on software proposed to be used in performing study.

D. Product Data: Submit the following:
   1. Short Circuit and Coordination Study: Summarize results of study in report format including the following:
      a. Descriptions, purpose, basis, and scope of study.
      b. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties, and commentary regarding same.
      c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
      d. Fault current calculations including definition of terms and guide for interpretation of computer printout.
   2. Incident energy and flash protection boundary calculations.
      a. Arcing fault magnitude
      b. Device clearing time
      c. Duration of arc
      d. Arc flash boundary
      e. Working distance
      f. Incident energy
      g. Hazard Risk Category
      h. Recommendations for arc flash energy reduction

E. Submit copies of final report signed by professional engineer. Make additions or changes required by review comments from EEOR.

1.6 QUALITY ASSURANCE

A. Maintain one copy of document on site.

B. Use commercially available software, designed specifically for short circuit and protective device coordination studies with minimum of 5 years availability approved by Architect/Engineer.

C. Perform study in accordance with IEEE 242.

1.7 QUALIFICATIONS

A. Study Preparer: Company specializing in performing work of this section with minimum 5 years experience.

B. Perform study under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of California five years' experience in power system analysis.

C. Demonstrate company performing study has capability and experience to aid during system start up.

1.8 SEQUENCING

A. Allow 2 weeks for review of completed study by Architect/Engineer.

B. Submit short circuit protective device coordination study and arc flash hazard analysis studies to Architect/Engineer prior to receiving final approval of distribution equipment shop drawings and prior to releasing equipment for manufacturing.

C. When formal completion of study will cause delay in equipment manufacturing, obtain approval from Architect/Engineer for preliminary submittal of study data sufficient in scope to ensure selection of device ratings and characteristics will be satisfactory.

1.9 SCHEDULING

A. Schedule work to expedite collection of data to ensure completion of study for final approval of distribution equipment shop drawings prior to release of equipment for manufacturing.

1.10 COORDINATION

A. Coordinate work with local power company.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

A. Aid electrical distribution system equipment manufacturer during start up of electrical system and equipment.

3.2 ADJUSTING

A. Perform field adjustments of protective devices and modifications to equipment to place equipment in final operating condition. Adjust settings in accordance with approved short circuit and protective device coordination study.

3.3 ARC FLASH WARNING LABELS

A. The vendor shall provide a 4 in. x 6 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have an orange header with the wording, “WARNING, ARC FLASH HAZARD”, and shall include the following information:
   1. Location designation
   2. Nominal voltage
   3. Flash protection boundary
   4. Incident energy
   5. Working distance
   6. Engineering report number, revision number and issue date

C. Labels shall be machine printed, with no field markings

D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
   1. For each 600, 480 and applicable 208-volt panelboards and disconnects, one arc flash label shall be provided
   2. For each motor control center, one arc flash label shall be provided
   3. For each low voltage switchboard, one arc flash label shall be provided
   4. For each switchgear, one flash label shall be provided
   5. For medium voltage switches one arc flash label shall be provided

3.4 AVAILABLE FAULT CURRENT LABEL

A. The vendor shall provide a 4 in. x 6 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have the wording, “AVAILABLE FAULT CURRENT”, and shall include the following information:
   1. Project Name
   2. Fault Name
   3. Available Fault Current
   4. Voltage
   5. Date of Calculation

3.5 ARC FLASH TRAINING

A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, shall be provided in the equipment manuals. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

END OF SECTION

SECTION 262200

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Aluminum-wound transformer meeting US Department of Energy proposed Candidate Standard Level (CSL) 3 efficiency, with extremely low no load losses.
   1. Transformers shall be designed to an efficiency standard higher than NEMA TP-1, the lowest legal efficiency for the following purposes:
   2. Delivering lowest life cycle cost according to the US Dept. of Energy
   3. Contributing to LEED Energy & Atmosphere Credit 1 (Optimize Energy Performance)
   4. Providing the basis for Utility Rebates.

B. Transformers designed to the lowest legal efficiency standard, thus not providing the contributions listed above, are not acceptable for meeting the requirements of this specification.

C. Transformer efficiency performance is the essence of this specification. Therefore, trans-formers shall meet the specified performance values, Transformers that are supplied on the project will be tested for conformance with these performance values. Transformers not meeting the specified performance values shall be removed and replaced.

D. Related Sections:
   1. Section 26 05 33 - Raceway and Boxes for Electrical Systems.
   2. Section 26 05 53 – Identification for Electrical Systems.

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA ST 1 - Specialty Transformers (Except General Purpose Type).
   2. NEMA ST 20 - Dry Type Transformers for General Applications.
   3. NEMA TP 1 Efficiency Standards.

B. DOE (Department of Energy)
   1. Standard Level Three (CSL-3) for Energy Efficiency.
   2. DOE 78 FR 23335 (April 18, 2013), Energy Conservation Standards for Distribution Transformers.

C. International Electrical Testing Association:
   1. ANSI/NETA ATS 2017 - Acceptance Testing Specifications for Electrical Power Equipment and Systems.

D. California Code of Regulations Title 20 and Title 24.

E. IEEE C57.110-1998 – IEEE Recommended Practice for establishing transformer capability when feeding non-sinusoidal load currents

F. IEEE-1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

G. LEED – Leadership in Energy and Environmental Design, U.S. Green Building Council.

H. ISO 9000:2000 – International Standards Organization - Quality Management System

I. ISO 14000:2004 – International Standards Organization - Environmental Management System

1.3 SUBMITTALS

A. Product Data: Submit outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type, and rated temperature rise.

B. Seismic Qualification: Submit manufacturer's certificate of seismic compliance in accordance with the American Society of Civil Engineers ASCE/SEI 7-05 and the California Building Code.

C. Submit product data including the following:
   1. Copy of ISO 14001:2004 Certification
   2. Copy of ISO 9001:2000 Certification
   3. Documentation of the integrated transformer meter, and how it interfaces to education for sustainability software.
   4. Insulation system impregnant data sheet as published by supplier.
   5. Construction details including enclosure dimensions, kVA rating, primary & secondary nominal voltages, voltage taps, BIL, unit weight
   6. Basic Performance characteristics including insulation class, temperature rise, core and coil materials, impedances & audible noise level, unit weight
   7. Inrush Current (typical 3 cycle recovery)
   8. Short Circuit Current data: Primary (Sym. O/P S/C) & Secondary (L-N/G S/C)
      a. Efficiency Data
      b. No load and full load losses per NEMA ST20
      c. Linear load Efficiency data @ 1/6 load
      d. Linear load efficiency data @ ¼, ½, ¾ & full load
      e. Linear Load Efficiency @ 35% loading tested per NEMA TP-2.
      f. Efficiency under K-4 load profile at 15%, 25%, 50%, 75%, 100% of nameplate rating.
   9. Description of manufacturer's factory nonlinear load test program
      a. Factory ISO 9001 procedure describing nonlinear load test program
      b. Meter and CT details including model, accuracy, serial numbers, and calibration information.
      c. Copy of Linear & Nonlinear load test report for a representative 75-kVA transformer
   10. 25-year Product Warranty Certificate
      a. Documentation that materials used for shipment packaging meet the environmental requirements identified in section 1.4 below. Provide a representative picture of the packaging materials.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

B. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the 2006 International Building Code.

C. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
   1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared, and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
   2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
   3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.5 MANUFACTURER'S FACTORY NONLINEAR LOAD TEST PROGRAM

A. The nonlinear load bank shall consist of a phase-neutral loading with a K-4 profile, representative of a mix of typical commercial equipment.

B. Meters and CTs shall both be revenue class accurate. CTs shall be operated within their approved accuracy loading range. Dual meters shall gather simultaneous primary and secondary energy and harmonic data. Meter and CT details including model, accuracy, serial numbers, and calibration information.

C. Efficiency: Measurements shall be taken at multiple load levels and plotted to show compliance with specification and correlation to the designed efficiency curve.

D. Efficiency shall be determined purely by measurements using method and instrumentation per NEMA TP-2 Standard. Other methods are not acceptable.

E. Harmonic data including current and Voltage THD at the different load levels shall be included with the test report.

1.6 PACKAGING FOR SHIPMENT

A. Transformers shall be packaged for shipment using materials that will have the least environmental impact:
   1. Transformer Wrapping
      a. Transformers shall be wrapped for shipment in a film coating that is 100% compostable and biodegradable.
   2. Transformer Shipping Base
      a. Transformers shall be shipped on a base that uses at least 50% less wood than traditional pallets.
      b. Wood used in the shipping base shall be Forestry Stewardship Council (FSC) certified as having been sustainably harvested.
   3. Shall minimize or eliminate use of materials that are not commonly recycled at the destination.
   4. Shall minimize labor, risk of injury and equipment damage, while handling from initial

transportation through to final placement of the transformer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

1.8 WARRANTY

A. Transformer shall carry a 25-year pro-rated warranty, which shall be standard for the product line.

1.9 ON-SITE PERFORMANCE VALIDATION

A. To ensure that the products shipped to the job site meet this specification, provide on-site revenue class accurate efficiency and harmonic measurements of transformers once in-stalled and operating at customer’s site. Data shall be collected from primary and secondary sides of the transformer simultaneously on a synchronized cycle by cycle basis. The use of two discrete meters that are not synchronized is not acceptable. Sampling shall be of 10% of transformers on the project once installed and operating, as selected by custom-er.

B. Demonstrate use of the transformer’s integrated efficiency and power quality meter where specified.

1.10 INTERNATIONAL STANDARDS ORGANIZATION REGISTRATION

A. Registration to current ISO standard is required.

B. Independent annual audits are conducted.

C. ISO 9001:2000 Registered – Quality Management System

D. ISO 14001:2004 Registered – Environmental Management System

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS/PRODUCT

A. Power smiths International Corp. (“OPAL” Series) OR others meeting the Performance requirements of this specification.

B. Manufacturers wishing to have products evaluated for acceptability and conformance with the performance requirements of this specification, shall provide detailed compliance and/or exception statements, along with the documentation identified in Section 1.3 (above) and test documentation, signed by an engineer, that confirms that the transformer(s) meet the no load losses and efficiency levels identified in Section 2.3 (below).

C. Failure to provide the required documentation no less than 7 days prior to the bid date will

disqualify products from consideration for this project.

D. Primary Voltage: 480 volts, 3 phases.

E. Secondary Voltage: 208Y/120 volts, 3 phases.

F. Compatibility: This product must facilitate the ability of the electrical system to supply a sinusoidal voltage in order to improve the long-term compatibility of the electrical system with all types of linear and nonlinear connected loads today and in the future. All national and international standards on harmonics and power quality set limits on levels of voltage distortion to maintain compatibility.

G. Aluminum-wound, 3-phase, common core, ventilated, dry-type, isolation transformer built to NEMA ST20 and relevant NEMA, UL and IEEE standards; 200% rated neutral; 60Hz rated; Transformers 750 kVA and less, 600 volts primary and less, shall be U.L. and CSA Listed and bear the label. All terminals, including those for changing taps, must be readily accessible by opening a lockable hinged door. Windings shall be continuous with terminations brazed or welded. 10kV BIL.

H. Insulation System:
   1. Shall be NOMEX-based with an Epoxy Co-polymer impregnant for lowest environmental impact, long term reliability and long-life expectancy
      a. Class: 220°C
      b. Impregnant Properties for low emissions during manufacturing, highest reliability, and life expectancy
      c. Epoxy co-polymer
      d. VOC: less than 1.65 lbs./gal. (low emissions during manufacturing)
      e. Water absorption (24hrs @25°C): less than 0.05% (superior insulation, longer life)
      f. Chemical Resistance: Must have documented excellent performance rating by supplier
      g. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
      h. Dissipation Factor: max. 0.02 @25°C to reduce aging of insulation, extending useful life

I. Operating Temperature Rise: 130°C in a 40°C maximum ambient

J. Noise levels:
   1. Per NEMA ST-20
   2. Production Test every unit. Data to be available upon request.

K. UL Listed & Labeled K-Rating: K-4 or higher

L. Maximum No Load Losses shall not exceed:
   1. 15kVA: 60W
   2. 30kVA: 99W
   3. 45kVA: 130W
   4. 75kVA: 185W
   5. 112.5kVA: 260W
   6. 150kVA: 325W
   7. 225kVA: 450W

8. 300kVA: 570W
9. 500kVA: 850W
10. 750kVA: 1200W

M. Efficiency at 1/6 loading shall meet or exceed:
1. 15kVA: 97.0%
2. 30kVA: 97.6%
3. 45kVA: 97.8%
4. 75kVA: 98.3%
5. 112.5kVA: 98.5%
6. 150kVA: 98.4%
7. 225kVA: 98.6%
8. 300kVA: 98.7%
9. 500kVA: 98.8%
10. 750kVA: 98.9%

N. Shall meet or exceed DOE 10 CFR Part 430 CSL 3 Efficiency requirements, tested per NEMA TP-2:
1. 15kVA: 97.6%
2. 30kVA: 98.1%
3. 45kVA: 98.3%
4. 75kVA: 98.6%
5. 112.5kVA: 98.8%
6. 150kVA: 98.9%,
7. 225kVA: 98.9%
8. 300kVA: 99.0%
9. 500kVA: 99.1%
10. 750kVA: 99.2%

O. Efficiency under k-4 nonlinear load at 50% of nameplate rating:
1. 15kVA: 97.2%
2. 30kVA: 97.7%
3. 45kVA: 97.9%
4. 75kVA: 98.1%
5. 112.5kVA: 98.5%
6. 150kVA: 98.7%
7. 225kVA: 98.8%
8. 300kVA: 98.8%
9. 500kVA: 98.9%
10. 750kVA: 99.1%

P. Voltage Taps: For transformers 30kVA-300kVA, provide two 2-1/2% full capacity taps above and below nominal primary voltage. For transformers 15kVA and smaller as well as 500kVA and larger provide one 5% full capacity tap above and below nominal primary voltage.

Q. Impedance: Between 3.5% and 5.8% unless otherwise noted.

R. Enclosure type: Ventilated NEMA 2, drip-proof

S. Maximum Footprint for 130°C rise model in a NEMA 2 enclosure:

1. 18” Wide x 17” Deep x 27” High for 15kVA.
2. 26” Wide x 18” Deep x 30” High for 30kVA, 45kVA
3. 32” Wide x 22” Deep x 40” High for 75kVA, 112.5kVA
4. 38” Wide x 27” Deep x 48” High for 150kVA
5. 38” Wide x 32” Deep x 52” High for 225kVA, 300kVA
6. 52” Wide x 38” Deep x 61” High for 500kVA
7. 64” Wide x 47” Deep x 67” High for 750kVA

T. ACCESSORIES
1. Manufacturer to provide a hinged access door on the front of the transformer with a built-in keyed lock.
2. 360-degree rotatable IR port.
3. Provide Lug Kit: Supply with standard screw-type lugs
4. Nameplate: Include transformer connection data.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify mounting supports are properly sized and located including concealed bracing in walls.

3.2 EXISTING WORK

A. Disconnect and remove abandoned transformers.

B. Maintain access and adequate ventilation to existing transformers and other installations remaining active and requiring access and ventilation. Modify installation or provide access panel or ventilation grilles.

C. Clean and repair existing transformers to remain or to be reinstalled.

3.3 INSTALLATION

A. Follow all national, state, and local codes with respect to transformer installation.

B. Set transformer plumb and level.

C. Use flexible conduit, in accordance with Section 26 05 33, 2 feet minimum length, for primary and secondary connections to transformer case. Make conduit connections to side panel of enclosure, except for floor mounted transformers fed from directly below enclosure.

D. Adjust transformer secondary voltages to provide the required voltage at the loads.

E. Transformers not specifically designed for wall mounting shall be spaced a minimum of 6 inches from adjacent walls, ceiling, and equipment.

F. Support transformers in accordance with Section 26 05 29.
1. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by manufacturer.
2. Mount floor-mounted transformers on vibration isolating pads suitable for isolating transformer noise from building structure.

3. Mount trapeze-mounted transformers as indicated on Drawings.

G. Provide seismic restraints where required.

H. Mount floor-mounted transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

I. Unless labeled otherwise, ventilated transformers shall have all sides located at least 6 inches away from walls or other obstructions.

J. Provide grounding and bonding connected to the following:
1. Primary feeder ground
2. Secondary feeder ground
3. Grounding electrode
4. Main bond jumper to neutral (when present).

3.4 FIELD QUALITY CONTROL

A. Upon completion of the installation, an infrared scan shall be provided for all bolted connections. Correct any deficiencies.

B. Adjust transformer secondary voltages to provide the required voltage at the loads.

C. Provide visual and mechanical inspection in accordance with NETA ATS, 7.2.1.1A.

D. Perform electrical tests in accordance with NETA ATS, 7.2.1.1B.

E. Provide written test results of insulation test and thermographic survey to Architect.

F. PERFORMANCE VALIDATION: To ensure that the products shipped to the job site meet this specification, provide on-site revenue class accurate efficiency and harmonic measurements of transformers once installed and operating at customer's site. Data shall be collected from primary and secondary sides of the transformer simultaneously on a synchronized cycle by cycle basis. The use of two discrete meters that are not synchronized is not acceptable. Sampling shall be of 10% of transformers on the project once installed and operating, as selected by customer. Submit a detailed report to the project engineer.

G. Where provided, connect the transformer's integrated efficiency and power quality meter to customer's building management system, network, or other system as specified.

3.5 ADJUSTING

A. Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION

SECTION 262416

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes distribution and branch circuit panelboards.

B. Related Sections:
   1. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
   2. Section 26 05 53 - Identification for Electrical Systems.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:
   1. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. National Electrical Manufacturers Association:
   1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
   2. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
   3. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.
   4. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
   5. NEMA PB 1 - Panelboards.
   6. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.

C. International Electrical Testing Association:
   1. ANSI/NETA ATS 2017 - Acceptance Testing Specifications for Electrical Power Equipment and Systems.

D. Underwriters Laboratories Inc.:
   1. UL 67 - Safety for Panelboards.
   2. UL 1449 – Surge Protection Devices.

1.3 SUBMITTALS

A. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

B. Product Data: Submit catalog data showing specified features of standard products and list the following information:
   1. Panel designation
   2. Voltage rating
   3. Current rating
   4. Top, bottom or through feed lugs, lug size

5. Main overcurrent device size.
6. Branch device schedule, listing size and poles
7. Surface trim or recessed.
8. Fault current rating of the panel and devices
9. Circuit breaker mounting method - bolt-in.
10. Bus material.
11. Indicate any special requirements including key locking, split bus, contactor panels, double panels, or panels in special NEMA enclosures.
12. Indicate which panelboards are electronic grade.

C. Seismic Qualification: Submit manufacturer's certificate of seismic compliance in accordance with the American Society of Civil Engineers ASCE/SEI 7-05 and the California Building Code.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of panelboards and record actual circuiting arrangements.

B. Operation and Maintenance Data: Submit spare parts listing; source of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

B. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the California Building Code.

C. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared, and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.6 MAINTENANCE MATERIALS

A. Furnish two of each panelboard key. Panelboards keyed alike.

PART 2 - PRODUCTS

2.1 BRANCH CIRCUIT PANELBOARDS

A. Manufacturers:
   1. Square D.

B. Product Description: NEMA PB1, circuit breaker type, lighting, and appliance branch circuit panelboard.

C. Panelboard Bus: Copper, current carrying components, ratings as indicated on Drawings. Furnish copper ground bus in each panelboard. Furnish isolated ground bus were indicated on Drawings.

D. Ground Bus: 50% capacity of the phase bus with lugs and terminals for terminating the sizes and quantity of ground conductors indicated and required.

E. Provide 200 percent rated, plated copper, solid Neutral.

F. Minimum fully rated Short Circuit Rating:
   1. 10,000-amperes RMS at 208V, or as shown on Drawings.
   2. 35,000-amperes RMS at 480V, or as shown on Drawings.

G. Panelboard breakers shall match the kAIC rating and manufacturer of the enclosure.

H. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles, Class A ground fault interrupter circuit breakers as indicated on Drawings.
   1. Circuit breaker handle locks shall be provided for all circuits that supply emergency egress lights, energy management and control system (EMCS) panels and fire alarm panels.
   2. Circuit breakers shall be molded case, thermal magnetic trip type with common trip handle for all poles.

I. Include adjustable trip breakers where required to achieve selective coordination or limit fault current as coordinated with the results of the contractor prepared power system study.

J. When indicated on the drawings provide a microprocessor-based GE ASPERMETER Series Panelboard Monitoring System. The system shall be provided with all features and requirements necessary to interface with the existing campus GE PMCS Systems and the existing campus JCI Metasys system. Upgrades in the existing GE PMCS and Metasys systems shall be provided as necessary to integrate the panelboard metering system.

K. Main circuit breakers shall be bus connected to the panel, vertically mounted, and not group aligned in branch breaker positions, include lock off hardware.

L. Enclosure: NEMA PB 1, Type 1.

M. Cabinet Box: 6 inches deep, 20 inches wide.

N. Trim: Cabinet front with concealed trim clamps and flush lock all keyed alike. Trim shall be dead front with metal frame index holder on inside of door. Panelboard enclosures shall be provided with either a flush or surface trim as indicated in the Panelboard Schedule or shown on the plan. Trim shall be painted baked on ANSI #61, light gray enamel. Covers shall be hinged so that they swing away to provide full access to the interior of the panel without removing the cover. Covers designed for more than one panel section shall not be permitted. Hinged type door covering all circuit breakers shall be included in all panel trims.

2.2 SURGE PROTECTION DEVICES

A. Electrical Requirements

1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
4. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

	Protection Modes			
Configuration	**L-N**	**L-G**	**L-L**	**N-G**
Wye	●	●	●	●
Delta	**N/A**	●	●	**N/A**
Single Split Phase	●	●	●	●
High Leg Delta	●	●	●	●

5. Nominal Discharge Current (In) – All SPDs applied to the distribution system shall have a 20kA in rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an in less than 20kA shall be rejected.
6. ANSI/UL 1449 4th Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 4th Edition VPR for the device shall not exceed the following:

MODES	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

B. SPD Design

1. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
2. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression

platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.

3. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
4. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
5. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:
    a. Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
        1) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.
        2) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
    b. Remote Status Monitor – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
    c. Audible Alarm and Silence Button – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
    d. Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.
        1) The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.
6. Overcurrent Protection
    a. The unit shall contain thermally protected MOVs. These thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall

disconnect the MOV(s) from the system in a fail-safe manner should a condition occur, that would cause them to enter a thermal runaway condition.

7. Fully Integrated Component Design – All of the SPD's components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.
8. Safety Requirements
   a. The SPD shall minimize potential arc flash hazards by containing no user serviceable / replaceable parts and shall be maintenance free. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
   b. SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

C. System Application
   1. The SPD applications covered under this section shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B, and A environments.

D. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category			
CATEGORY	Application	Per Phase	Per Mode
B	Distribution Panelboards	160 kA	80 Ka
A	Branch Panelboards	120 kA	60 kA

E. SPD Type – All SPDs installed on the load side of the service entrance disconnect shall be Type 1 or Type 2 SPDs.

PART 3 - EXECUTION

3.1 EXISTING WORK

A. Disconnect abandoned panelboards. Remove abandoned panelboards.

B. Maintain access to existing panelboard remaining active and requiring access.

C. Clean and repair existing panelboards to remain or to be reinstalled.

3.2 INSTALLATION

A. Install panelboards in accordance with NEMA PB 1.1.

B. Install panelboards plumb.

C. Install recessed panelboards flush with wall finishes.

D. Maximum height: 6’-6” to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above floor.

E. Install filler plates for unused spaces in panelboards.

F. Provide 8 ½” by 11” minimum typed circuit directory with clear plastic covering inside panel door for each branch circuit panelboard. Contractor shall clearly identify locations and specific purpose of circuits.

G. Schedules shall include:
   1. Panel designation.
   2. Panel location.
   3. Voltage, phase, current rating.
   4. Main overcurrent device size.
   5. Branch circuit listing indications circuit number and description of loads served.
   6. Source of panel feeder.
   7. Panel schedule book shall be assembled based on "As Built" information and submitted to the University upon completion of the project. Provide one hard copy of book and provide one CD or Zip-disk containing updated panel schedules in MS Excel format.

H. Install engraved plastic nameplates in accordance with Section 26 05 53.

I. Install spare conduits out of each recessed panelboard to accessible location above ceiling. Minimum spare conduits: 3 empty 1 inch. Identify each as SPARE.

J. Ground and bond panelboard enclosure according to Section 26 05 26. Connect equipment ground bars of panels in accordance with NFPA 70.

3.3 FIELD QUALITY CONTROL

A. Perform visual and mechanical inspections listed in NETA ATS, Section 7.6.1.1.A.

B. Perform tests listed in NETA ATS, Section 7.6.1.1.B.

3.4 ADJUSTING

A. Adjust all variable trip circuit breakers to the proper setting for the load each circuit breaker is protecting. Retest to verify the setting is correct and adjust as needed. After the settings are completed, record the panel number, device number with the load trip point that the device has been adjusted for and the name and size of the load on a typed separate sheet of paper. Place one copy of this paper in the panel directory pocket and provide one copy with each operation and maintenance manual.

END OF SECTION

SECTION 262726

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wall switches; receptacles; multioutlet assembly; and device plates and decorative box covers.

B. Related Sections:
   1. Section 26 05 33 - Raceway and Boxes for Electrical Systems: Outlet boxes for wiring devices.

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA WD 1 - General Requirements for Wiring Devices.
   2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's catalog information showing dimensions, colors, and configurations.

B. All switches, receptacles and device plates throughout project shall be from the same manufacturer unless otherwise specified.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

PART 2 - PRODUCTS

2.1 WALL SWITCHES

A. Manufacturers:
   1. Pass & Seymour
   2. Leviton
   3. or equal

B. Product Description: Industrial Grade, NEMA WD 1, Heavy-Duty, AC only quiet toggle switch.

C. Body and Handle: Ivory thermoplastic with toggle handle red color for devices connected to emergency power system.

D. Wiring: Back and side wired. Back wiring with clamp type terminals suitable for stranded or solid wire.

E. Indicator Light: Separate pilot strap; red color lens.

F. Locator Light: Lighted handle type switch; green color handle.

G. Ratings:
   1. Voltage: 120-277 volts, AC.
   2. Current: 20 amperes.

2.2 RECEPTACLES

A. Manufacturers:
   1. Pass & Seymour
   2. Hubbell
   3. Leviton
   4. Cooper
   5. Approved equal

B. Product Description: Specification Grade, NEMA WD 1, Heavy-duty general use receptacle. Grounding system shall be all brass and integral to the wrap around mounting strap. Combination head brass grounding screw. Brass alloy triple wipe contacts shall grip both sides of plug prongs.

C. Device Body: Ivory thermoplastic. Red for devices connected to Emergency circuits. Red for devices connected to Emergency circuits.]

D. Wiring: Back and side wired. Back wiring with wrap-around steel strap clamp type terminals suitable for stranded or solid wire.

E. Configuration: NEMA WD 6, type as indicated on Drawings.

F. Convenience Receptacle: Duplex type 5-20.

G. GFCI Receptacle: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

H. Tamper Resistant Receptacle: Convenience receptacle with internal spring-loaded mechanical shutter. Type 5-20.

I. Special Purpose Receptacles: Type and rating and number of poles indicated or required for the anticipated purpose.

2.3 WALL PLATES

A. Color, Material and Locations:
   1. Stainless Steel: Brushed stainless steel with stainless steel screws at all locations, except as indicated below.
   2. Unfinished Areas: In tunnels, above ceilings and in unfinished areas, device plates shall be galvanized steel utility type.

3. Weatherproof Outlets: Provide cast aluminum plate with a hinged backing double lift cover and gasket allowing either surface or recessed mounting. Plate shall allow horizontal mounting of a duplex receptacle with a horizontal hinge. Hubbell #5205 or equal for standard boxes or Hubbell #5206 or equal for FS boxes. GFI outlets shall be provided with an appropriate cover.

B. Weatherproof Wet Location Cover Plate: Extended polycarbonate hinged cover for use when attachment plug is inserted.

2.4 MULTIOUTLET ASSEMBLY

A. Multi-outlet Assembly: Sheet metal channel with fitted cover, suitable for use as multi-outlet assembly.

B. Size: As indicated on Drawings.

C. Receptacles: Furnish covers and accessories to accept receptacles specified in this Section.

D. Receptacles: NEMA WD 6, type 5-15R.

E. Receptacle Spacing: As indicated on Drawings.

F. Channel Finish: Gray enamel.

G. Fittings: Furnish manufacturer's standard couplings, elbows, and connectors

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify outlet boxes are installed at proper height.

B. Verify wall openings are neatly cut and completely covered by wall plates.

C. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

A. Clean debris from outlet boxes.

3.3 EXISTING WORK

A. Disconnect and remove abandoned wiring devices.

B. Modify installation to maintain access to existing wiring devices to remain active.

C. Clean and repair existing wiring devices to remain or to be reinstalled.

3.4 INSTALLATION

A. Install devices plumb and level.

B. Mounting heights shown shall be measured from finished floor to the center of the outlet box.

C. Install switches with OFF position down.

D. Install all outlet boxes for light switches flush in wall where possible. Where more than one switch appears at the same location, they shall be installed in a ganged box with a single plate.

E. Where receptacles are shown adjacent to other devices, the boxes shall be installed with 2" between devices of other systems.

F. Install receptacles with grounding pole on top.

G. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor.

H. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

I. Terminate ground wire at device where ground wire is provided within the raceway system.

J. Carefully strip thermoplastic wire to length and make-up terminal connection as recommended by the device manufacturer.

K. Secure device to outlet box with proper screws.

L. Use jumbo size plates for outlets installed in masonry walls.

M. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.

3.5 Labels and Inscriptions:

A. Identify receptacle cover plate with panel and branch circuit number (for example L2A-3). Engrave and fill with 1/8” high black letters. Red for emergency system outlets.

3.6 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes provided under Section 26 05 33 to obtain mounting heights as specified and as indicated on drawings.

3.7 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify each receptacle device is energized.

D. Test each receptacle device for proper polarity and grounding.

E. Test each GFCI receptacle device for proper operation.

3.8 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.9 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 262819

ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fusible and non-fusible switches.

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA FU 1 - Low Voltage Cartridge Fuses.
   2. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. International Electrical Testing Association:
   1. ANSI/NETA ATS - 2017Acceptance Testing Specifications for Electrical Power Equipment and Systems.

1.3 SUBMITTALS

A. Product Data: Submit switch ratings and enclosure dimensions.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCH ASSEMBLIES

A. Manufacturers:
   1. Square D.

B. Product Description: NEMA KS 1, Type HD, enclosed load interrupter knife switch. Handle lockable in OFF position.

C. Fuse clips: Designed to accommodate NEMA FU 1, Class R fuses.

D. Enclosure: NEMA KS 1, to meet conditions. Fabricate enclosure from [steel finished with manufacturer's standard gray enamel.
   1. Interior Dry Locations: Type 1.
   2. Exterior Locations: Type 3R.

E. Furnish switches with entirely copper current carrying parts.

2.2 NONFUSIBLE SWITCH ASSEMBLIES

A. Manufacturers:
   1. Square D.

B. Product Description: NEMA KS 1, Type HD enclosed load interrupter knife switch. Handle lockable in OFF position.

C. Enclosure: NEMA KS 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.
   1. Interior Dry Locations: Type 1.
   2. Exterior Locations: Type 3R 4X stainless steel.

D. Furnish switches with entirely copper current carrying parts.

2.3 SWITCH RATINGS

A. Switch Rating: Horsepower rated for AC or DC as indicated on Drawings.

B. Short Circuit Current Rating:
   1. Non-Fused Switches: UL listed for 10,000 rms symmetrical amperes.
   2. Fused Switches: UL listed for 10,000 rms symmetrical amperes when used with or protected by Class H or K fuses (30-600 ampere) 200,000 rms symmetrical amperes when used with or protected by Class R or Class J fuses (30-600 ampere switches employing appropriate fuse rejection schemes).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install enclosed switches plumb. Provide supports in accordance with Section 26 05 29.

B. Install fuses for fusible disconnect switches.

C. Install engraved plastic nameplates in accordance with Section 26 05 53.

D. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

3.2 FIELD QUALITY CONTROL

A. Provide visual and mechanical inspections per NETA ATS 7.5.1.1.A.

END OF SECTION

SECTION 262823

ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes molded-case circuit breakers in individual enclosures.

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

B. International Electrical Testing Association:
   1. ANSI/NETA ATS – 2017 Acceptance Testing Specifications for Electrical Power Equipment and Systems.

1.3 SUBMITTALS

A. Product Data: Submit catalog sheets showing ratings, trip units, time current curves, dimensions, and enclosure details.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

PART 2 - PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKER

A. Manufacturers:
   1. Square D.

B. Product Description: Enclosed, molded-case circuit breaker conforming to NEMA AB 1. Circuit breakers with frame sizes 250 amperes and larger shall have a field adjustable variable magnetic trip element.

C. Minimum fully rated Short Circuit Rating:
   1. 10,000-amperes RMS at 208V, or as shown on Drawings.
   2. 35,000-amperes RMS at 480V, or as shown on Drawings.

D. Panelboard breakers shall match the kAIC rating and manufacturer of the enclosure.

E. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles, Class A ground fault interrupter circuit breakers as indicated on Drawings.

1. Circuit breaker handle locks shall be provided for all circuits that supply emergency egress lights, energy management and control system (EMCS) panels and fire alarm panels.
2. Circuit breakers shall be molded case, thermal magnetic trip type with common trip handle for all poles.

F. Include adjustable trip breakers where required to achieve selective coordination or limit fault current as coordinated with the results of the contractor prepared power system study.

G. Accessories: As indicated on Drawings. Conform to NEMA AB 1.

H. Enclosure: NEMA AB 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.
1. Interior Dry Locations: Type 1.
2. Exterior Locations: Type 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install enclosed circuit breakers plumb. Provide supports in accordance with Section 26 05 29.

B. Height: 5 feet to operating handle.

C. Locate and install engraved plastic nameplates in accordance with Section 26 05 53.

3.2 FIELD QUALITY CONTROL

A. Provide circuit breaker visual and mechanical inspection in accordance with NETA ATS, 7.6.1.1.A.

END OF SECTION

SECTION 265100

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes interior luminaires, lamps, ballasts, and accessories.

B. Related Sections:
   1. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
   2. Section 26 05 33 - Raceway and Boxes for Electrical Systems.

1.2 REFERENCES

A. Underwriters Laboratory
   1. UL 8750-09 - Light Emitting Diode (LED) Light Sources for Use in Lighting Products.

1.3 SUBMITTALS

A. Product Data: Submit dimensions, ratings, and performance data.

B. Provide lighting fixtures complete with lamps, completely wired, controlled, and securely attached to supports.

C. Contractor shall provide entire lighting specification (including fixture catalog cuts and sketches) for each specified manufacturer with complete information about the fixtures they will supply.

D. Type of fixtures shall be as indicated alphanumerically and as specified.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES

A. Product Description: Complete interior luminaire assemblies, with features, options, and accessories as scheduled.

2.2 LED LIGHT FIXTURES

A. General:
   1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.

2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
3. LED drivers shall include the following features unless otherwise indicated:
   a. Minimum efficiency: 85% at full load.
   b. Minimum Operating Ambient Temperature: -20˚ C. (-4˚ F.)
   c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
   d. Integral short circuit, open circuit, and overload protection.
   e. Power Factor: ≥ 0.90.
   f. Total Harmonic Distortion: ≤ 20%.
   g. Comply with FCC 47 CFR Part 15.
4. LED modules shall include the following features unless otherwise indicated:
   a. Comply with IES LM-79 and LM-80 requirements.
   b. Minimum CRI 90 and color temperature 3000˚ K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
   c. Minimum Rated Life: 50,000 hours per IES L70.
   d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.
5. LED lamps shall be capable of continuous dimming, without flicker or noise, from 10-100 percent.

PART 3 - EXECUTION

3.1 EXISTING WORK

A. Disconnect and remove abandoned luminaires, lamps, and accessories.

3.2 INSTALLATION

A. Provide mounting accessories as required for ceiling construction. Fixture catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a fixture may be installed.

B. Provide adequate and sturdy support for each lighting fixture. Verify weight and mounting method of fixtures and furnish and install suitable supports. Fixture mounting assemblies shall comply with local seismic codes and regulations.

C. Install suspended luminaires using pendants supported from swivel hangers. Install pendant length required to suspend luminaire at indicated height.

D. Support luminaires independent of ceiling framing.

E. Locate recessed ceiling luminaires as indicated on Reflected Ceiling Plan.

F. Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prevent movement.

G. Exposed Grid Ceilings: Support surface-mounted luminaires on grid ceiling directly from building structure.

H. Install recessed luminaires to permit removal from below.

I. Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.

J. Install clips to secure recessed grid-supported luminaires in place.

K. Install wall-mounted luminaires at height as indicated on Drawings.

L. Install accessories furnished with each luminaire.

M. Connect luminaires to branch circuit outlets provided under Section 26 05 33 using flexible conduit not exceeding 6 feet.

N. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

O. Lighting fixtures recessed in ceilings which have a fire resistive rating of 1 hour or more shall be enclosed in a box which has a fire resistive rating equal to that of the ceiling.

P. Ground and bond interior luminaires in accordance with Section 26 05 26.

3.3 FIELD QUALITY CONTROL

A. Operate each luminaire after installation and connection. Inspect for proper connection and operation.

3.4 CLEANING

A. Remove dirt and debris from enclosures.

B. Clean photometric control surfaces as recommended by manufacturer.

C. Clean finishes and touch up damage.

END OF SECTION

SECTION 270500
COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes, but is not necessarily limited to, common standards and procedures for the Communications Work.

B. This Section outlines areas of responsibility between Owner, Architect, and Contractor.

C. Owner will assist with a collaborative process to determine the most cost effective and efficient means to reach the common goal of providing communications within the facility for the project, including assessing user needs and assessing required pathways. The Owner is available upon request to assist at no additional cost to the project. It is incumbent upon the construction team management to approach and engage the Owner at the appropriate times for collaboration.

D. As part of the project, the construction team must design, engineer, and provide complete, all means of support, suspension, attachment, fastening, bracing, and restraint (hereinafter "support") of the Communications Systems; and provide engineering of such support by parties licensed to perform work of this type in the project jurisdiction.

1.2 ITEMS PROVIDED BY OWNER

A. Registered Communications Distribution Designer (RCDD) support services

B. IT project management

C. Submittal approvals

D. Network equipment

E. 802.11 Wireless Access Point hardware

1. Installation by construction team when wireless access point mounting requires seismic support or a construction activity such as screwing, drilling, or welding
2. Owner will provide 802.11 design services

F. Rack and Stack

G. Plug Pack Distribution (Pre-terminated switch port cabling provided and installed by the Owner)

H. Patch Cords and Patching

I. VOIP Router, Voice Gateway, VOIP equipment

J. Camera NVR/Server

K. Overhead Paging Amplifier

L. TV Distribution Amplifier

M. Closet Cleaning postproduction

1.3 ITEMS PROVIDED BY CONSTRUCTION TEAM

A. Building Drawings and Floor Plans

B. Site Plans

C. Furniture Plans

D. As-Built Drawing Submittals
   1. Cabling Schedule

E. Attachments to structure

F. In wall cabling

G. In wall cabling supports

H. Wireless Access point installation

I. Cabling test results

J. Patch Panels

K. Horizontal Wire Managers

L. Horizontal cable, jacks, faceplates, surface mount boxes, cable trays, termination hardware, and all materials needed for a complete horizontal cabling plant as defined in the Section and associated Sections and the construction documents not otherwise listed for provision by the Owner.

M. Construction Clean Closet Cleaning

1.4 RELATED SECTIONS

A. 27 05 26 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

B. 27 05 29 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

C. 27 05 33 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

D. 27 05 36 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

E. 27 05 53 IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

F. 27 11 16 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

G. 27 11 19 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 27 11 23 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 27 11 26 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 27 13 00 COMMUNICATIONS BACKBONE CABLING

K. 27 13 43 COMMUNICATIONS SERVICES CABLING

L. 27 15 00 COMMUNICATIONS HORIZONTAL CABLING

M. 27 53 19 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.5 REFERENCES AND STANDARDS

A. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid. Consider such codes or standards a part of this Specification as though fully repeated herein.

1. UC Davis Health Telecommunications Standards
2. American National Standards Institute (ANSI)
3. Telecommunications Industry Association (TIA)
4. Building Industry Consulting Services International (BICSI)
5. American Society for Testing and Materials (ASTM)
6. Institute of Electrical and Electronic Engineers (IEEE)
7. National Electrical Manufacturers Association (NEMA)
8. Underwriters Laboratories, Inc. (UL)
9. Local Authorities Having Jurisdiction (AHJ)

B. Codes: Perform Work executed under this Section in accordance with applicable requirements of the latest edition of governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:

1. United States Department of Labor (DOL) Regulations (Standards - 29 CFR)
2. Part 1910, “Occupational Safety and Health Standards”

3. California Code of Regulations (CCR) Title 24, California Building Standards Code Part 2, Basic Building Regulations and Part 3, California Electrical Code (CEC).
4. 2016 California Building Code (CBC).
5. 2016 California Fire Code (CFC).
6. 2016 California Mechanical Code (CMC).
7. National, State and any other binding building and fire codes.
8. FCC Regulations:
    a. Part 15 – Radio Frequency Devices & Radiation Limits
    b. Part 68 – Connection of Terminal Equipment to the Telephone Network
9. Underwriter's Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
    a. UL 444: Communications Cables
    b. UL 497: Protectors for Paired-Conductor Communication Circuits.
    c. UL 1651: Optical Fiber Cable
    d. UL 1690: Data-Processing Cable
    e. UL 1963: Communications-Circuit Accessories
    f. UL 2024A: Optical Fiber Cable Routing Assemblies.
10. ANSI/TIA/EIA-568-D Commercial Building Telecommunications Cabling Standard.
11. ANSI/TIA/EIA-569-E Commercial Building Standard for Telecommunications Pathways and Spaces.
12. ANSI/TIA/EIA-598-B Optical Fiber Cable Color Coding.
13. ANSI/TIA/EIA-606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
14. ANSI/J-STD-607-D Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
15. ANSI/TIA/EIA-758 Customer-Owner Outside Plant Telecommunications Cabling Standard.
    a. TIA/EIA-758-1 Addendum No. 1
16. EIA testing standards.
17. Insulated Cable Engineers Association (ICEA):
    a. ANSI/ICEA S-80-576-2002 Category 1 & 2 Individually Unshielded Twisted Pair Indoor Cables for Use in Communications Wiring Systems
    b. ANSI/ICEA S-83-596-2016 Fiber Optic Premises Distribution Cable
    c. ANSI/ICEA S-87-640-2016 Fiber Optic Outside Plant Communications Cable
    d. ANSI/ICEA S-90-661-2012 Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cable for Use In General Purpose and LAN Communication Wiring Systems

e. ICEA S-104-696-2019 Standard for Indoor-Outdoor Optical Cable

18. Telecommunications Distribution Methods Manual (TDMM)

1.6 ABBREVIATIONS

A. ADA Americans with Disabilities Act

B. AFC Above Finished Ceiling

C. AFF Above the Finished Floor

D. BDF Building Distribution Frame – See Telecommunications Room (TR)

E. BLDG Building

F. CAT Category (Related to network cable types)

G. DIV Division

H. (E) Existing

I. ER IT Equipment Room – See Telecommunications Room (TR)

J. GE Grounding Equalizer – Part of the Telecom Grounding System

K. HR Homerun

L. ID Inside Diameter

M. IDF Intermediate Distribution Frame – See Telecommunications Room (TR)

N. IT UC Davis Health IT Department (also UC, UCDH, UCD IT, IT Facilities)

O. LAN Local Area Network

P. MAX Maximum

Q. NIC Not in Contract

R. OD Outside Diameter

S. TBB Telecom Bonding Backbone – Part of the Telecom Grounding System

T. TGB Telecommunications Ground Busbar

U. TMGB Telecommunications Main Ground Busbar

V. TR Telecommunications Room, TR may also be used interchangeably with ER, IDF, MDF, or Communications Room

W. TYP Typical

X. UCD UC Davis Health IT Department (also UC, UCDH, UCD IT, IT Facilities)

Y. UFE University Furnished Equipment

Z. UON Unless Otherwise Noted

1.7 DEFINITIONS

A. Telecommunications Room (TR) – An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

B. Intermediate Distribution Frame (IDF) – See Telecommunications Room (TR)

C. Entrance Facility (EF) (Telecommunications) – An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

D. Pathway – A physical infrastructure utilized for the placement and routing of telecommunications cable.

E. "Cabling": A combination of cables, wire, cords, and connecting hardware [e.g., cables, conductor terminations, connectors, outlets, patch panels, blocks, and labeling].

F. "Identifier": A unique code assigned to an element of the telecommunications infrastructure that links it to its corresponding record.

1.8 QUALITY ASSURANCE

A. Contractor Firm Qualifications:

1. All work for the Communications (low voltage) Infrastructure installation shall be self-performed by the Communications Contractor; subcontractors shall not be allowed under the Communications Contractor.

B. Communications Contractor shall:

1. Be a Panduit Corp. PCI (Panduit Certified Installer) Design and Installation Contractor or approved equal.
2. Be a firm which is regularly and professionally engaged in the installation and testing of the specified communications equipment and infrastructure.
3. Be licensed to install low voltage electronic cabling systems in the State of California where applicable (C7 License).

C. Communications Contractor shall demonstrate experience in providing successful installation of data infrastructure systems:

1. Submit documentation for a minimum of three and a maximum of five successful low voltage communications infrastructure system installation projects completed within the past three years.

D. Contractor Key Personnel Qualifications:

1. Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified low voltage communications systems, equipment and infrastructure. There may be one key person or more key persons proposed for this project depending upon how many of the key roles each has successfully provided.
2. Each of the key personnel shall demonstrate experience in providing successful low voltage communications systems, equipment and infrastructure within the past three years.

E. A Registered Communications Distribution Designer (RCDD) shall be employed by the Design Builder and directly engaged in the project for all Communications Infrastructure design and installation efforts.

1. The RCDD shall be a direct employee of the Communications Contractor, within the Design Build team structure.
2. The RCDD shall be required to have oversight and supervision of the entire Communications Infrastructure installation process and quality control.
3. The RCDD shall be the Design Builder's Designer of Record for the Communications Infrastructure scope of work.
4. RCDD direct responsibilities shall include but may not be limited to: Thorough coordination with Owner regarding all design and installation efforts related to the project. A Pre-construction coordination meeting and site inspection with Owner prior to beginning any work. Oversight of Communications installation efforts, development of shop drawings and assembly of product data submittals. Quality control review and stamping of finalized Communications as-built drawings for submittal to Owner. Quality control review of Communications systems installation throughout the entire construction phase, to ensure all work is performed in compliance with approved construction drawings.

F. Critical on-site quality control installation reviews to be conducted in conjunction with Owner technical staff shall include but may not be limited to:

1. Verifying proper installation of all Communications cable tray, backbone conduits, device back boxes, conduit infrastructure and cabling pathways. Site inspection and sign-off must be performed prior to concealing conduit infrastructure and prior to the installation of any low-volt cabling.
2. Verifying proper installation of all Communications cabling. Site inspection and sign-off must be performed prior to closing-up associated accessible ceilings.
3. Verifying the layout and installation of all equipment and cabling within the Telecom Rooms, throughout the duration of the construction phase.

G. Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel. Submit documentation for a minimum of three and a maximum of five successful cabling system installations for each of the key personnel in an environment resembling that which is being bid upon.

1. In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of three years' experience in the installation of the specified copper and fiber optic cable and components. The personnel on site performing work pertaining to this job shall be certified on the system being installed. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.
2. Submit documentation for a minimum of three and a maximum of five successful cabling system installations for each of the key personnel in an environment resembling that which is being bid upon. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this project. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems.
3. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this project.
4. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project Owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

H. Indicate that all key persons are currently employed by the Communications Contractor or have a commitment to the Communications Contractor to work on this project. All key persons shall be employed by the Communications Contractor at the date of issuance of this project, or if not, have a commitment to the Communications Contractor to work on this project by the date that the bid was due to the Owner's Representative.

1. Note that only the key personnel approved by the Owner's Representative in the successful proposal shall perform work on this project's low voltage systems, equipment and infrastructure. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the Communications Contractor's key personnel require approval from the Owner's Representative.

I. Designated Supervisor: Designate which key person will serve as a designated supervisor for the project. This supervisor shall be present and responsible for the project site during all phases of installation and testing of the Work in this Section. This supervisor shall be the same individual through the execution of the Work unless illness, loss of personnel, or other circumstances reasonably beyond the control of the Contractor intervene.

J. Submit documentation for a minimum of three and a maximum of five successful low voltage systems, equipment, and infrastructure installations for each of the key personnel.

K. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the low voltage communications systems, equipment and infrastructure proposed for this project. Include specific experience in installing and testing communications systems and provide the names and locations of at least two project installations successfully completed using systems and equipment substantially similar to those specified for this project.

L. All the existing low voltage communications systems, equipment and infrastructure installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this project.

M. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project Owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

1.9 SUBMITTALS

A. All Submittals shall be provided electronically in PDF format. All Drawing Submittals shall be provided in PDF and AutoCAD (latest version) .DWG format.

B. Submittals shall be organized in a coordinated package complete with all information specified herein. Incomplete or uncoordinated submittals will be returned with no review action.

C. Contractor shall submit the following items:

1. Contractor Key Personnel and Certifications
2. Complete Bill of Materials (BOM) List
3. Manufacturer Product Data Sheets, as defined below
4. Shop Drawings, as defined below.
    a. Data outlet location.
    b. Cable routing.
    c. Data Rack Elevation including network work equipment.
5. Proposed Installation Schedule
6. Cabling Certification Test Plan and proposed test equipment

D. Manufacturer Product Data Submittals shall include:

1. Submit product data sheets for all equipment being provided.
2. Collate in sequence by Section Number, and clearly mark proposed product on data sheet. Include Safety Data Sheet, where applicable.
3. Clearly identify any proposed product substitutions or known deviations.

E. Precede each submittal book with a summary TOC. per example schedule below:

1. Specification Section
2. Drawing Reference
3. Manufacturers Model No.

F. The following is a general summary list of Submittal items required to be delivered at 30-day burn-in period.

1. As part of project close-out activities, Contractor shall submit Record Documents for review and approval by the Owner.
2. All Record Documents shall be provided electronically in PDF format. All Record Document Drawings shall be provided in PDF and AutoCAD (latest version) DWG format.

1.10 CLOSEOUT SUBMITTALS

A. Contractor shall submit the following items:

1. Record As-Built Shop Drawings indicating the final, 'as-built' condition of all associated equipment, infrastructure, and work.

B. Shop Drawing Submittals shall include:

1. Drawing index/symbol/schedule sheet.
2. Clearly indicate all new work versus existing work.
3. Site Plans, Floor Plans, and Reflected Ceiling (work 7' AFF+) Plans
4. Drawings shall be developed in AutoCAD .DWG format, utilizing most current architectural backgrounds available for the project.
5. All drawings shall be properly scaled.
6. Indicate all device locations and types. Include addressing for all network outlets (as
7. Indicate all cabling routes, types and quantities.
8. Indicate all conduit routing, quantities, sizes, and wire fill. Indicate basket tray and J-hook routes.
9. Indicate fire stopping requirements for all penetrations.
10. Indicate 'cable bundle groups' no larger than:
    a. CAT5e – 52
    b. CAT6 – 64
    c. CAT6A – 74
11. When bundling low voltage cabling together the lowest common denominator determines the largest cable group allowed unless the cable is LP listed.

C. Riser Diagrams indicating:

1. Backbone cabling and termination locations. Associated cabling pathways, sizes and cable fill. Telecommunications Grounding System.

D. Enlarged Room Plans and Elevations indicating:

E. Provide dimensioned drawings for all telecommunications rooms. Complete, dimensioned rack and wall elevations of all equipment. Consideration must be given to equipment heights within. Plywood backboards and grounding equipment.

F. Racks, cabinets, cable tray, ladder rack, wire management. Termination equipment for all copper and fiber cabling. Conduit and cable entrance points and fire stopping. Electrical panels, power circuits and HVAC provisions.

G. Ensure coordinated arrangement of equipment with other trades. Typical Device Installation Details indicating: J-hooks, conduit, cable tray, and associated support systems. Network outlet faceplate layout and wiring terminations. Device back box and conduit rough-in requirements.

H. Details of other associated devices and equipment.

I. The shop drawing package must be stamped and signed by a Registered Communications Distribution Designer (RCDD). Signatures by a Professional Engineer (PE) licensed in the project jurisdiction for work of this type as required by the AHJ.

J. Cable Certification Test Results. Submit electronically and include associated software license as applicable.

K. Completed punch list reports.

L. Manufacturer Operation and Maintenance (O&M) Manuals.

M. Warranty information.

N. Keys and any portable equipment.

1.11 WARRANTY SERVICE

A. Closeout Submittals, Warranties and Guarantees, provide the following.

1. Response Time: Provide a qualified technician familiar with the work at the project site within four hours after receipt of a notice of malfunction. Provide the Owner's Representative with telephone number attended 10 hours a day, five days a week, to be called in the event of a malfunction.

2. Provide all Warrantees as defined in each Communication Systems Section.

B. PanGen Structured Cabling Solutions System Warranty

1. Contractor shall provide a Panduit Certification Plus System Warranty on all installed copper and fiber permanent links. Such warranty shall provide a complete system warranty to guarantee high end-to-end performance for all applications designed to operate over the

class of cabling installed. The guarantee shall include all connectivity components and cable within the permanent link and cover the system for duration of 25 years.

PART 2 - MATERIALS

2.1 COMMUNICATIONS SYSTEMS PRODUCTS SUMMARY

A. The following is a general summary list of Communications Systems equipment, components, and cabling required for the project. This is not intended to be a comprehensive list of materials. See additional Sections for complete materials requirements.

B. Racks: Cooper B-line SB85219096FB (seismic) I SB556096XUFB. Racks will be eight foot for new builds and remodels where space is available. Seven foot racks will be used as an alternate where space is not available for taller racks. Wire Managers: Panduit PEV Series full height vertical cable manager.

C. Wire Managers: Panduit PE2V Series full height vertical cable manager.

1. 10" Wide Front/Back unless otherwise noted on plans
2. 96 inch or 84 inch sized to match the racks being installed.

D. Telecommunications Ground Bar (TGB) CPI_Mfg.Part:40153-012

E. Data Patch Panels: Panduit CP48WSBLY

F. Fiber Terminations: LC

G. Modular Jack CAT6A

1. Panduit Mini-Com CJ6X88TGVL
2. Colored Icons as needed per UC service designation
3. Icons are Panduit PAN_CID(XX) (gray for cables in ceiling)

H. Copper cabling, Category 6A (Data)

1. High Speed, TIA Category 6A cabling, Plenum Rated
2. General Cable GenSpeed 6A Part No. 7141877 Purple
3. General Cable GenSpeed 6A Part No. 7151855 Purple
    a. Use of the improved Genspeed cable is dependent on availability. Do not default to this cable if lead times are excessive.

I. Copper cabling, Category 6A Shielded (Overhead Paging)

1. High Speed, TIA Category 6A Shielded cabling, Plenum Rated
2. General cable GenSpeed 6A Part No. 7131789

J. Telecommunications Outlets (Workstation side)

1. Modular Furniture Surface Mount Box, Black
2. Panduit CBXQxBL-A Where x =number of ports
3. Modular Surface Mount Box Attachment System - Mini-Com CBM-X magnetic
4. Modular Surface Mount Box Blank Insert - Panduit CMB(BL)

K. Faceplate (Workstation side)

1. Panduit Mini-Com Stainless Steel Faceplates Single Gang CFP {2,4,6} SY or Double Gang CFP {4,8,10} S-2GY
2. Faceplate Blank Insert – Panduit CMB(WH)

PART 3 - EXECUTION

3.1 TELECOMMUNICATIONS SPACES

A. Telecom Room (TR) minimum size 10' x 12'.

B. UC Davis Health Telecommunications Standards do not include provisions for AV, unless otherwise indicated in the Design Criteria for the project. IT will be cooperative in assessing some parameters as they interact with IT support systems.

C. Telecommunication Spaces are to use EZ-Path Fire-Rated Pathways systems for cabling access.

D. Provide 36" of working clearance in front and back of racks and electronic equipment.

E. A positive pressure type of HVAC system using hot and cold aisles.

F. Walls shall be covered with fire-resistant treated plywood, and all surfaces sealed to mitigate airborne dust.

G. IT uses a typical three-rack configuration with a B-line seismic for equipment and a standard 19" rack for cabling. Vertical wire management for planning shall be sized at 10" unless otherwise noted on the drawings.

3.2 RACK COMPONENTS AND ELEVATIONS

A. Owner will develop an equipment layout and rack elevation including the Telecom Room (TR) layouts. Typical components within the TR include, but not limited to:

1. Network Equipment
2. Fiber Termination Unit
3. UPS/ PDU I Power distribution
4. NM2/ NM4/ Horizontal wire management

5. VOIP Router/Voice Gateway
6. VOIP transition equipment
7. Voice cabling
8. Distribution Patch Panels
9. Clinical Engineering Equipment
10. Plug Pack Distribution
11. Camera NVR /Server
12. Nurse Call Devices
13. Overhead Paging Amplifier

B. See related Sections for materials provided by the Owner and those furnished by the Contractor.

3.3 EXAMINATION

A. Conditions: Verify conditions, provided under other sections, are acceptable for product installation in accordance with manufacturer's instructions.

B. Pathways: Verify that pathways and supporting devices, provided under other sections, are properly and permanently installed, and that temporary supports, devices, etc., have been removed.

C. Field Measurements: Verify dimensions of pathways, including length of pathways. For example, “true tape” the conduits to verify cabling distances.

3.4 FIELD QUALITY CONTROL

A. Staffing: Provide a qualified foreman who is in charge of the Work and who is present at the job site at times Work is being performed. Supervise the work force executing the Work. Perform the installation within the restraints of the construction schedule.

B. Project Management: Coordinate and attend weekly status meetings to review the overall progress and issues to be resolved throughout the course of construction. Prepare and distribute meeting agenda prior to and meeting notes after meetings in a format acceptable to the General Contractor.

C. Scheduling: Prepare an overall construction schedule based on the results of the planning meetings with the General Contractor. Issue schedule to General Contractor for approval. Prepare and issue updated schedules whenever there are modifications.

D. Inspection: Perform inspection after installation. Keep areas of work accessible and notify code authorities, or designated inspectors, of work completion released for inspection. Document completion, and inspection as required.

3.5 INSTALLATION

A. Conform to applicable federal, state and local codes, and telephone standards.

B. Attend one pre-construction meeting with the Owner to coordinate the requirements of the communications systems.

C. Coordinate the entire installation with the General Contractor, and their subcontractors, to meet the construction schedule. Include coordination meetings as required to fulfill this requirement.

D. Manufacturer's Instructions:

1. Comply with manufacturer's product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.

E. Maintain jobsite file and comply with Material Safety Data Sheets (MSDS) for each product delivered to jobsite.

3.6 REPAIR/RESTORATION

A. Replace or repair work completed by others that you deface or destroy. Pay the full cost of this repair/replacement.

B. Paint damaged areas to existing painted surfaces caused by Work.

C. Punch List:

1. Inspect installed work in conjunction with the General Contractor and develop a punch list for items needing correction.
2. Provide punch list to Owner for review prior to performing punch walk with Owner.

D. Re-Installation:

1. Make changes to adjust the system to optimum operation for final use. Make changes to the system such that any defects in workmanship are correct and cables and the associated termination hardware passes the minimum test requirements.
2. Repair defects prior to system acceptance.

E. Cleaning

1. Clean daily. Remove temporary coverings and protection of adjacent work areas. Remove unused products, debris, spills, or other excess materials. Remove installation equipment.
2. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.
3. Repair or replace damaged installed products.
4. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance. Legally dispose of debris.

3.7 DEMONSTRATION

A. On completion of the acceptance test, schedule a time convenient with the Owner or Owner's Representative for instruction in the configuration, operation, and maintenance of the system.

B. Provide 4 hours, minimum, of on-site orientation and training by a factory-trained representative. Document dates and times of training and submit a "sign in" sheet for individuals trained, as part of the close out documentation.

3.8 CERTIFICATION

A. Provide to Owner or Owner's Representative a written form of acceptance for signature. Corrections must be completed before Owner or Owner's Representative and Engineer will give acceptance.

END OF SECTION

SECTION 270526

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding of communications work, including but not limited to:
   1. Cable shields, communications racks, cabinets, and enclosures

1.2 SYSTEM DESCRIPTION

A. Provide telecommunications grounding system as described herein.

B. Except as otherwise indicated, the complete communications installation including the racks, cabinets, panels, cable tray, runway, lightning protectors cable shields and splice cases provided under the work of this project shall be completely and effectively grounded in accordance with all Code and Standards requirements, whether or not such connections are specifically shown or specified.

C. Resistance:
   1. Resistance from the farthest ground bus through the ground electrode to earth shall not exceed 5 Ohms or the requirements of ANSI-J-STD-607-D-2019, whichever is more restrictive.
   2. Resistance from Communications racks Buss ground to UFER ground must remain less than or equal to the electrical ground presented at A/C outlet for electronic equipment in the communications rack.

1.3 DEFINITIONS

A. Definitions as described in Section 270500 shall apply to this section.

1.4 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

C. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

D. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

E. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

F. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

G. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.5 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 270500

B. Strictly adhere to all Telecommunications Industry Association (TIA) recommended installation practices when installing Bonding and Grounding.

C. Material and work specified herein shall comply with the applicable requirements of:
1. TIA-568-D: Commercial Building Telecommunications Wiring Standard
2. TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces
3. TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
4. ANSI/TIA– 606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

1.6 WARRANTY

A. Match warranty Section 270500

PART 2 - PRODUCTS

2.1 TELECOMMUNICATIONS GROUNDING BUSBAR (TGB)

A. The Telecommunications Grounding Bus bar provides a central ground attachment point for telecommunications bonding backbones, TR equipment, racks, cable runways, sleeves, and other system located in the Telecommunications Room. All Grounding Bus bars shall be UL listed. Hole patterns on Bus bars accommodate two-hole lugs per the recommendation of BICSI and TIA-607 standards. Insulators electrically isolate Bus bars from the wall or other mounting surfaces.

B. Manufacturer:
1. CPI Mfg. Part: 40153-12

2. Or approved equal

2.2 GROUNDING AND BONDING CONDUCTORS

A. General purpose insulated: UL listed and code sized copper conductor, with dual rated THHN/THWN, insulation color identified green.

1. Cable jacket marking:
   a. Must be legible and shall contain the following information: Manufacturer's name
   b. Copper conductor gauge, UL listing
   c. Cable jacket shall be green with black lettering

B. Telecommunications Bonding Backbone cable:
1. 3/0 AWG THHN/THWN CU- Must be UL listed.

C. Telecommunications Bonding Conductor:
1. Sizing of the telecommunications bonding conductor per ANSIJ-STD-607-D
2. Size TBCs as the greater of 6 AWG or based on length of run using 1000CM/linear foot.

TBB/GE linear length m (ft)	**TBB/GE size (AWG)**
less than 4 (13)	6
4 - 6 (14 - 20)	4
6 - 8 (20 - 26)	3
8 - 10 (26 - 33)	2
10 - 13 (33 - 44)	1
13 - 16 (44 - 52)	1/0
16 - 20 (52 - 66)	2/0
20 - 26 (67 -84)	3/0
26 - 32 (85 - 105)	4/0
32 - 38 (106 - 125)	250 kcmil
38 - 46 (126 -150)	300 kcmil
46 - 53 (151 - 175)	350 kcmil
53 - 76 (176 - 250)	500 kcmil
76 - 91 (251 - 300)	600 kcmil
Greater than 91 (301)	750 kcmil

D. Manufacturers:

1. General Cable
2. Harger Lightning & Grounding
3. Or approved equal

2.3 COMPRESSION CONNECTOR LUG

A. Long-barrel compression lugs shall be used on all ground wire. Copper alloy body.
   1. Provide lug size to match conductor being terminated.
   2. Provide 2-hole pattern lugs.
   3. Provide each lug with silicon bronze hardware, including 2 bolts, 2 split lock washers and 2 nuts.
   4. UL listed.

B. Manufacturer:
   1. Panduit.
   2. Harger Lightning & Grounding GECLBxxx (xxx depending on cable Size).
   3. Or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the execution requirements of Section 270500.

3.2 EXAMINATION

A. Examine existing Telecommunications Grounding Backbone system prior to the start of work within this section. The Telecommunications Contractor is solely responsible to ensure work proposed within this section is fully compatible, in the opinion of the Engineer, with the existing Telecommunications Grounding Backbone system.

3.3 CONNECTIONS TO STRUCTURAL STEEL, GROUND RODS, OR SPLICES

A. Where required by the Specifications, grounding conductors shall be spliced together, connected to ground rods, or connected to structural steel using exothermic welds or high-pressure compression type connectors.

B. Exothermic welds shall be used for cable-to-cable and cable-to-ground rod and for cable to structural steel surfaces. Exothermic weld kits shall be as manufactured by Harger Lightning & Grounding, Cadweld, Thermoweld or approved equal. Each weld shall use a kit unique to that type of weld.

C. High-pressure compression type connectors shall be used for cable-to-cable connections. Connections shall be as manufactured by Thomas & Betts #53000 series, Burndy "Hy-Ground or approved equal.

3.4 GENERAL EXECUTION

A. Provide Grounding & Bonding according to the most restrictive requirements of ANSI-J-STD-607-B, California Electrical Code Article 250, and references therein and California Electrical Code Article 800.
   1. In the event of conflicting requirements, California Electrical Code requirements shall prevail.

B. Contractor shall supply all materials required to furnish and install a complete functional telecommunications grounding system.

C. The grounding system shall be installed in accordance with the manufacturer's instructions and as indicated on Contractor's submittal documentation, prior to final acceptance/approval by the University.

D. Point of connection:
   1. Under Work of this Section, install a complete Telecommunications Grounding System, leaving only the physical connection between the TMGB and Building Service Entrance Ground for work under Division 26 Electrical.

E. Ground bar installation
   1. The C-10 Contractor shall install a ground bar in each Telecom Room to which all ground wires, grounding terminal points within the room, and Telecommunications Bonding Backbone conductors will terminate.

F. Telecommunications Bonding Conductor:
   1. Install TBCs in a manner that will protect them from physical and mechanical damage.
   2. Routing:
      a. Route TBCs in the shortest possible path, using right-angles for turns and routed parallel to building lines.
      b. Utilize a minimum 1-foot bend radius.
   3. At TMGB/TGBs:
      a. Thoroughly clean non electro tin-plated busbar prior to fastening the conductors, bolts, or connectors to the busbar.
      b. Attach lugs to busbar with appropriate size cadmium bronze bolt, flat washer and Belle-ville washer.
   4. Torque connections.

G. Rack Bay & Overhead Cable Support Bonding
   1. Rack Bay: Bond equipment racks, frames, frame bays, cabinets, server racks, and other similar support systems located within the same room or space as the TMGB/TGB to the busbar.
   2. Overhead Cable Support:
      a. Bond overhead runway located within the same room or space as the TMGB/TGB to the busbar.
      b. Provide “grounding kit” (straps & connectors) to bond sections of cable runway for ground continuity. This requirement shall apply to sections of cable runway within a single communication room.

3.5 LABELING

A. General Requirements
   1. Labeling, identifier assignment, and label colors shall conform to TIA/EIA-606-A Administration Standard and as approved by Owner's Representative before installation.
   2. Permanently label TBCs. Affix label as close as practical to each end of the conductor.

B. Label Format
   1. Labels shall be permanent with machine-generated text; handwritten labels will not be accepted.
   2. Labels on TBCs shall fully wrap around conductors with a self-laminating feature to provide permanent marking.

C. Identifier Assignment
   1. Separate label fields of the identifier with a hyphen.
   2. TBC:
      a. First field: "TBC" (the bonding conductor type).
      b. Second field: The room identity where TBC exists; for example: "B01-TDA".
      c. Third field: A unique sequential number; for example: "01", "02", etc.
      d. Example: "TBC–B01-TDA–01"

3.6 RECORDS

A. Communication Bonding System records shall conform to TIA/EIA-606-C Administration Standards. Each component shall have as a minimum, the information as outlined in TIA/EIA-606-C.

3.7 ACCEPTANCE

A. Review bonding configuration after all cabling and equipment is installed for approval by project IOR representative.

END OF SECTION

SECTION 270529

HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, and services to completely execute the provision of communications supports and cable hook system as described in this specification, including but not limited to:
   1. Strut supports
   2. Cable hooks (J-hooks)
   3. Beam clamps
   4. Concrete fasteners
   5. Touch-up materials
   6. Conduit supports
   7. Equipment supports
   8. Fastening hardware
   9. Poke-through device

1.2 SYSTEM DESCRIPTION

A. Provide devices specified in this Section and related Sections for support of communications equipment specified for this project.

B. Provide support systems that are adequate for the weight of equipment, conduit and wiring to be supported.

1.3 SEISMIC REQUIREMENTS

A. Seismic design requirements criteria, as shown on all drawings related to the project, including architectural and structural, as defined below shall apply to all work defined within the following specification sections:
   1. SECTION 270500 COMMUNICATIONS HORIZONTAL CABLING
   2. SECTION 270526 GROUNDING AND BONDING OF COMMUNICATIONS SYSTEMS
   3. SECTION 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS
   4. SECTION 271116 COMMUNICATIONS CABINETS RACKS FRAMES AND ENCLOSURES
   5. All support systems and termination apparatus associated with the telecommunications system.

B. Contractor to install seismic restraints for all telecommunications racks and UPS systems. In accordance with construction documents. Include floor mounted items weighing more than 400 pounds and wall mounted or suspended items weighing more than 20 pounds.

C. Installation according to engineered drawings and anchorage calculations provided by the structural engineer in accordance with California Code of Regulations, Title 24, 2007 California Building Code.

D. Supports for such items, including racks, conduit, cable trays and similar shall provide support, bracing, and anchorage, designed by the structural engineer in accordance with CBC Chapter 16A.

E. Supports to be sized to suit load and selected to match mounting conditions

1.4 REFERENCES

A. Comply with References requirements of Section 270500

B. In additional to those codes, standards, etc., listed in Section 27 05 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
1. ASTM A 510 Specifications for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
2. ASTM B 633 Specifications for Electrodepositing Coatings of Zinc on Iron and Steel, Sections SC2 and SC3.
3. ASTM A 653 Specifications for Steel Sheet, Zinc-Coated (Galvanized) by Hot Dip Process.
4. ASTM A 591 Specifications for Electrodepositing Coatings of Zinc on steel wire or sheets.
5. ASTM A 123 Specifications for Zinc (Hot Galvanized) Coatings on Iron and Steel.

1.5 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

D. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

E. 270553 IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

F. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

G. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.6 DEFINITIONS

A. Definitions as described in Section 270500 shall apply to this section.

B. “Cable Hanger”: A metal, most often steel, cable support device shaped (section view) similar to the letter J; alternately, a fabric strap. The device is available in different sizes supporting different quantities of cables and is also available with different attachment hardware to be supported by different methods (e.g., wire support, beam flange clip, etc.).

C. Cable Runway or Ladder Rack: Overhead means to get cabling from point to point whether it be vertical or horizontal within Telecommunications Spaces such as TR’s and the TER.

D. “J-Hook”: Another name for cable hangers.

PART 2 - PRODUCTS

2.1 FASTENERS, STRAPS, AND BEAM CLAMPS

A. Equal products by the following manufacturers will be considered providing that all features of the specified product are provided:
   1. Concrete fasteners
      a. Hilti.
      b. Phillips "Red-Head."
      c. Remington.
      d. Ramset.
      e. Simpson Strong-Tie.
      f. Or approved equal.
   2. Concrete inserts and construction channel:
      a. Unistrut Corp.
      b. GS Metals "Globe Strut."
      c. Thomas & Betts.
      d. "Kindorf" Corp.
      e. Or approved equal.

   3. Conduit straps:
      a. 0-Z/Gedney.
      b. Erico "caddy" Fastening Products.
      c. Thomas & Betts.
      d. "Kindorf" Corp.
      e. Or approved equal.
   4. Beam Clamps
      a. Cooper B-line.

b. SuperStrut.
c. Unistrut.
d. Or approved equal.

2.2 CABLE HANGERS

A. Ceiling Hung J-Hooks
1. Specifically intended to carry the load of up to 74 communications cables without applying excess forces to cables at bottom of bundle.
2. Integral broad bottom edge to spread cable load with flat bottom and provide a minimum of 1-5/8" cable bearing surface.
3. Integral hanger rod attachment hardware at top. Load rated for application.
4. Incorporates smooth 90-degree radius edges to prevent snagging cable jackets on installation.
5. Designed so the mounting hardware is recessed to prevent cable damage.
6. Integral mechanical cable latch retainer to provide containment of cables within the hook. The retainer shall be removable and reusable.
7. Suitable for direct attachment to walls, hanger rods, beam flanges, purlins, strut, floor posts, etc.to meet job conditions.
8. Multi-tiered cable hooks to be used where required to provide separate cabling compartments, or where additional capacity is needed.
9. Finishes: cable hooks for non-corrosive areas shall be pre-galvanized steel, ASTM A653. Where additional strength is required, cable hooks shall be spring steel with a zinc-plated finish, ASTM B633, SC3.
10. Cable hooks for corrosive areas shall be stainless steel, AISI Type 304.
11. Manufacturer:
a. Cooper B-Line series BCH21, BCH32, BCH64.
b. Caddy/Erico cablecat.
c. Or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Executive requirements of Section 270500.

3.2 EXAMINATION

A. Thoroughly examine site conditions for acceptance of supporting device installation to verify conformance with manufacturer and specification tolerances. Notify the University's Representative of conditions that would adversely affect the installation or subsequent utilization of the system. Do not proceed with installation until unsatisfactory conditions are corrected.

B. Installer is responsible for the integrity of the structures to which the system is attached, including their capability of safely accepting the loads imposed as evaluated by a qualified engineer.

C. The University's Representative reserves the right to request additional supports where in their sole opinion said supports are required. Any additional supports shall be installed at no additional cost to the University.

3.3 PREPARATION

A. Prepare and maintain the following clearances from EMI sources (per BICSI Standards).
   1. Power cable (in grounded conduit) = 6 inches
   2. Power cable (unshielded) = 24 inches
   3. Fluorescent lights = 5 inches
   4. Transformers = 48 inches

B. Provide all low voltage Communications Systems Pathways and Electronic Security and Safety System Pathways.

3.4 DISTRIBUTION PATHWAY VIA CEILING HUNG CABLE HOOKS (J-HOOKS)

A. The cabling support system shall be installed in accordance with the manufacturer's instructions and as indicated on Contractor's submittal documentation, prior to final acceptance/approval by the University.

B. Provide dedicated supports at sixty inches (60”) separation, maximum, per a given route. Suspend wire or rod using components appropriate for the structure – e.g., powder-actuated clip fastener for wire, beam flange clip or angled flange clip for either wire or rod, or an embedded anchor for the threaded rod. Do not share support (wire/rod) with other trades. Do not support the hanger on ceiling grid support wires. Do not support the hanger from ductwork, piping, or other equipment hangers.

C. Cable Tray cables are not to exceed a 25% fill when the project is complete. 25% fill is a visual fill of 50% of the cable tray.

3.5 CONDUIT

A. Conduit used for pathway is to be designed with a maximum 40% visual fill.

B. EZ path retrofit EZDR-400 or EZDR-200 will be provided on all conduits when required for compliance.

3.6 FLOOR BOXES AND POKE THROUGH DEVICES

A. All Floor boxes shall be sized and approved by UCD IT and FD&C's furniture group.
   1. Wiremold RC9AM2TCBK flush poke -thru with accessories as required.
   2. One 1-1/4" trade standard, data.
   3. One 1-1/2" trade standard, av or other.
   4. Floor poke through assembly, dual service feed-through fitting. Commonly used wire mold RC9AM2TCBK flush poke -thru with accessories as required. One 3/4" trade standard and one 1-1/4" trade standard.
   5. Wiremold 4ffatcbs flush furniture feed poke -thru with accessories as required.

6. Or approved equal.

END OF SECTION

SECTION 270533

CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide telecommunications pathways in accordance with ANSI TIA-569-E, as shown on the plans or as designed by an RCDD.

B. Provide conduits as required by fire code and where wall cavities are obstructed.

C. Provide Ring and String were allowed in wall cavities and locations are accessible.

D. Provide a minimum of a 1 ¼" conduit for wall drops as needed.

E. All junction boxes shall be sized and designed by a registered RCDD communications designer

F. Conduit for communications is NOT to adhere to the parallel of the exterior wall configuration required by the electrical specification. Cable Distance is priority for communications cabling and dictates path taken.

1.2 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

E. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

F. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

G. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.3 SUBMITTALS

A. Product Data: For each product indicated.

B. Submittals are to be approved by IT Facilities Department and consultant.
1. Obtain written approval from the Consultant for the product data submittal prior to materials and equipment purchase order and prior to installation.
2. Format: Submit each product data as an electronic (PDF) document.
3. Labeling: For each submittal, provide a cover page including the following information:
a. Client Name
b. Project Name and Address
c. Submittal Name (e.g., “Product Data Submittal for LCD Panel Backbox.”)
d. Specification Section Number (e.g., “Section 27 05 33).
e. Date of Submittal
f. Contractor Name

C. Submit conduit shop drawings for cable path other than wall drops.

D. Confirm low voltage pathway quantity and fill ratio expected.

E. Include junction box locations and sizes.

PART 2 - PRODUCTS

2.1 WORK AREA OUTLET BOX

A. Work area outlet box
1. 5 square deep boxes on wall drops where required

2.2 JUNCTION BOXES

A. Junction Boxes
1. Sized to accommodate bend radius of cabling being installed.

2.3 FLOOR BOXES, POKE-THROUGHS AND MONUMENTS

A. Floor Box, Flush Devices
1. All Floor boxes shall be sized and approved by IT facilities and FD&C’s furniture group.
2. Manufacturers
a. Wiremold RC9AM2TCBK Flush Poke -Thru with accessories as required.

B. Floor Poke Through Assembly, dual service feed-through fitting.
1. Commonly used

a. Wiremold RC9AM2TCBK Flush Poke -Thru with accessories as required.
   1) One 3/4" trade standard
   2) One 1-1/4" trade standard
b. Wiremold 4FFATCBS Flush Furniture Feed Poke -Thru with accessories as required.

2.4 WIRELESS, SECURITY AND OTHER PERIPHERAL CABLING INSTALLATIONS

A. Conduit and/or electrical outlet box shall not be installed for wireless access point installations unless required by AHJ or physical conditions of the area.

B. Consider the device being installed when calling out conduit and housings for security and peripheral devices due to differing requirements.

2.5 FIRE PENETRATIONS

A. EZ path retrofit EZDR-400 shall be provided where applicable as fire stop materials on all conduits.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Distribution Pathway via EMT Raceway:
   1. Structured cabling installation is to meet BICSI cable distance limitations. Remaining parallel to the building structure is not a requirement.
   2. All ends of conduits shall be cut square, reamed, and fitted with insulated bushing.
   3. All conduit which passes through firewalls shall adhere to applicable fire code.

3.2 PREPARATION

A. Fill ratios are to be calculated by the designer and installer during their respective design and installation phases of the project.

B. Cable Tray cables are not to exceed a 25% fill when the project is complete. 25% fill is a visual fill of 50% of the cable tray.

C. Conduit used for pathway is to be designed with a maximum 40% visual fill.

D. EZ path retrofit EZDR-400 or EZDR-200 will be provided on all conduits when required for compliance.

3.3 MOUNTING AND INSTALLATION – WORK AREA OUTLET BOX

A. Provide back boxes at all wall phones and employee time clocks.

B. The distance between pull boxes shall not exceed 100 feet.

C. Conduits exceeding two 90-degree bends shall be upsized to the next trade size and never exceed 240 degrees.

D. Support and fasten pathway and pull boxes as defined in the electrical specifications.

E. Conduit purposed for floor box(es) must have the respective conduit turn up in an adjacent or nearby wall or column that is stubbed to nearest accessible ceiling.

F. Manufacturer's instructions:
   1. Comply with manufacturer's product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.
   2. Maintain jobsite file of Material Safety Data Sheets (MSDS) for each product delivered to jobsite packaged with an MSDS.

3.4 PENETRATIONS

A. Provide EZ path fire penetrations where applicable.

B. Provide conduit penetrations per electrical Specifications.

3.5 STATION CABLE PATHWAY INSTALLATION

A. Work Area Outlet Boxes:
   1. Unless otherwise noted on the plans, all cut in boxes and surface station outlet boxes are to be installed at a height of 18" A.F.F. (above finished floor) to center, except for those otherwise called out.
   2. Those plates or boxes that are to be used for telephone wall jacks shall be installed according to ADA requirements.
   3. All cabling outlets shall be installed so that their edges are parallel to the vertical and horizontal edges of the surface on which they are mounted.

3.6 FINAL INSPECTION AND CERTIFICATION

A. Punch Walks and Punch Lists
   1. Punching the Work of individual Sections of Division 27 may be combined.
   2. Execute a punch walk with the Consultant to observe work.
   3. Develop a punch list for items needing correction. Issue this punch list to Consultant.
   4. Correct the Work as noted on punch list.
   5. Execute follow up punch walk with the Engineer and the Owner or Owner's Representative to verify punch list items have been corrected.

END OF SECTION

SECTION 270536

CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This section included cable trays in corridors and telecom spaces.

B. System components include cable runways (ladder rack), and wire basket trays.

1.2 SUBMITTALS

A. Submittal requirements:
   1. Submittals are to be approved by UCD IT and consultant.
   2. Provide shop drawings indicating cable tray does not to exceed 25% visually full when the project is complete. 25% full is a visual fill of 50%.
   3. Provide product data for the following:
      a. Manufacturer's data/cut sheets, product drawing/specifications and installation instructions for all products (submit with bid).
         1) Clearly mark the provided documentation to denote which part number/specific product is being submitted.

1.3 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

F. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

G. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.4 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the owner or owner representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated or a substitution is requested, equipment shall be equivalent in every way to that of the equipment specified. All substitutions are subject to the control and approval of the owner or the owner representative.

C. Strictly adhere to all BICSI, Telecommunications Industry Association (TIA) recommended installation practices when installing communications and data cabling.

D. Material and work specified herein shall comply with the applicable requirements of:
1. ANSI/TIA/EIA-569-E Commercial Building Standard for Telecommunications Pathways and Spaces.
2. ANSI/TIA/EIA-606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
3. ANSI/J-STD-607-D Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
4. BICSI – Telecommunications Distribution Methods Manual
5. NEMA – VE-1 – Metal Cable Tray Systems
6. NEMA – VE-2 – Metal Cable Tray Installation Guidelines

PART 2 - PRODUCTS

2.1 CABLE RUNWAY AND BASKET TRAY

A. Cable Runway (Ladder Rack)
1. Construction: Solid steel side bar per ASTM A-36 or tubular steel side bar per ASTM A-513.
2. 1.5" x 0.375 minimum tubular side stringers.
3. Accessories: Provide with a complete system of accessories, including radius corners at vertical and horizontal bends, section splice plates, expansion plates, blind-end plates, etc. Provide waterfall drop-outs at each end of cabling racks and cabinets or where needed to terminate open wiring systems.
4. Finish: Black powder coat
5. Manufacturers:
   a. B-Line Telecom-Saunders SB-17.
   b. Chatsworth Products Inc.11275 series.
   c. PW Industries
   d. Or approved equal.

B. Basket Tray
   1. Open Wire Frame Construction.
   2. Welded wire mesh with continuous safety edge wire lip.
   3. Mesh forms grid at nominally 2" by 4"
   4. Electroplated zinc galvanized carbon steel.
   5. Accessories: Provide a complete system of accessories, including bonding and grounding connections, conduit connectors, to terminate conduits extended to basket edge, radius shields to protect cabling at inside corners, and waterfall drop-outs at each end of cabling racks and cabinets or where needed to terminate open wiring systems.
   6. Manufacturers:
      a. Cablofil.
      b. PW Industries.
      c. Or approved equal.

C. Radius Cable Drop
   1. Provide and install Tool-less Cross Member Radius Drops for support and guiding of cable loads as they enter and exit the ladder rack runway, allowing cables to maintain proper bend radius.

PART 3 - EXECUTION

3.1 CABLE TRAY APPLICATION

A. Communications cable tray installations shall conform to the following:
   1. Ladder Rack - Wraps and traverses within communications rooms, as shown on construction drawings.
   2. Basket Tray- Horizontal station cabling outside of the communications rooms where more than 100 cables are within the pathway.

B. Size and Fill Ratio:
   1. Basket Tray is not to exceed 40% visually full when the project is complete. 25% full is a visual fill of 50%. Size as shown on the drawings.
   2. Ladder Rack size is typically 18" wide unless the room size prohibits access when installed. Install ladder rack as sized on the drawings.

3.2 INSTALLATION

A. Each of the cable tray systems shall be installed and supported in accordance with the manufacturer's instructions and as indicated on Contractor's submittal documentation, prior to final acceptance/approval by the University.

B. Installation shall be performed and accomplished in a professional manner, by qualified personnel.

C. Installation to maintain at least 12" vertical clearance over the top of each tray for use by University’s personnel.

D. Install end caps for all exposed ends. File and deburr ladder rack then place end caps on all exposed ends.

E. Ladder rack shall be securely bonded to the Telecommunications Grounding Busbar (TGB and TMGB). Attach a bonding conductor sized as defined in J-STD-607-D and as defined by local code or the authority having jurisdiction (AHJ) between the Telecommunications Grounding Busbar and the ladder rack. Attach the bonding conductor to the ladder rack using included hardware according to the manufacturer's installation instructions. The installer shall provide the bonding conductor and other necessary hardware required to make the connections between the ladder rack and the Telecommunications Grounding Busbar.

F. Provide access 24" wide along one side of each tray unless conditions will not allow such clearances. Deviation must be cleared by IT before installing tray. Conditions of installation not approved by IT shall be replaced at no cost to the University.

G. A minimum of 6 inches of clearance from the top of the finished ceiling to the bottom of the cable tray shall be provided.

H. Cable distance limitation of 275 ft shall be adhered to when laying out cable support infrastructure.

I. Cable fill ratio is not to be exceeded during the initial installation of cabling.

J. Separation of systems other than IT are the responsibility of the contractor. IT requires a separation of all non-Ethernet protocol systems from all Ethernet protocol systems installed.

K. Basket Tray shall not penetrate any firewall. EZ Path products shall be used as the solution with the cable or basket tray stopping short of the wall by 1 to 2 feet.

L. Where cable tray or basket tray becomes inaccessible, a transition to conduit shall be provided. If fire stopping is required at either end of the conduit(s), an EZ Path retrofit EZDR-400 shall be provided on all conduits.

END OF SECTION

SECTION 270541

FIRE-STOPPING SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Section includes: Firestopping for the following.
   1. Penetrations through fire-resistance-rated floor and roof construction including both empty openings and openings containing cables, pipes, ducts, conduits, and other penetrating items.
   2. Penetrations through fire-resistance-rated walls and partitions including both empty openings and openings containing cables, pipes, ducts, conduits, and other penetrating items.
   3. Penetrations through smoke barriers and construction enclosing compartmentalized areas involving both empty openings and openings containing penetrating items.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Comply with California Code of Regulations - Title 24, CBC - Chapter 7, Fire Resistance Ratings and Fire Tests.

B. Test Requirements:
   1. ANSI/UL 2079 Tests for Fire Resistance of Building Joint Systems, 2020
   2. ASTM E-814 Standard Test Method for Fire Tests of Penetration Firestop Systems, 2017
   3. ANSI/UL 1479 Standard for Fire Tests of Penetration Firestops, 2015

1.3 RELATED SECTIONS

A. Division 27 Communications Sections

1.4 SUBMITTALS

A. Procedure: In accordance with Division 01 and the following:

B. Data: Manufacturer product data, including UL Listing, for all materials and prefabricated devices and manufacturer's installation instructions. Submitted material must be approved by Campus Fire Marshal prior to installation.

C. Shop drawings detailing location of installed through penetration devices.

1.5 QUALITY ASSURANCE

A. Compatibility: Provide firestop systems compatible with one another and with substrates under conditions of application and service.

B. Firestop system installation must meet requirements of ASTM E-814, UL 1479, or UL 2079

tested assemblies that provide a fire rating equal to that of construction being penetrated.

C. All materials shall be new.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with through penetration firestop systems (XHEZ) listed in Volume II of the UL Fire Resistance Directory, provide products of the following, as required by condition of use:
   1. Specified Technologies, Inc.
      Somerville, NJ, telephone 800-992-1180

2.2 MATERIALS

A. All through penetrations shall be labeled on both sides of the wall to indicate the appropriate UL system number, product used, installation date, hour rating installer, location number and telephone contact for the corresponding manufacturer. Material installed shall be as required for installation conditions and to achieve the required fire resistance.

B. Use only firestop products that have been UL 1479, ASTM E-814, or UL 2079 tested for specific fire rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire rating involved for each separate instance.

C. For penetrations by non-combustible items including steel pipe, copper pipe, rigid steel conduit and electrical metallic tubing (EMT), the following materials are acceptable:
1. EZ-Path retrofit device sized for the conduit being installed.

D. For penetrations by combustible items (penetrants consumed by high heat aflame) including insulated metal pipe, PVC jacketed, flexible cable or cable bundles and plastic pipe (closed piping systems) the following materials are acceptable:
1. EZ-Path Fire Rated Pathway

E. For large size/complex penetrations made to accommodate cable trays, multiple steel and copper pipes, electrical busways in raceways the following materials are acceptable:
1. EZ-Path Fire Rated Pathway

F. Provide a firestop system with a "F" Rating as determined by UL 1479 or ASTM E-814 which is equal to the time rating of construction being penetrated.

G. Provide a firestop system with an Assembly Rating as determined by UL 2079 which is equal to the time rating of construction being penetrated.

H. For workstation conduits from accessible ceiling to outlet.
1. STI Spec Seal putty.

I. For pipe penetrations of cast in place concrete floors and concrete over metal decking the following material is acceptable:
   1. EZ-Path

PART 3 – EXECUTION

3.1 PREPARATION

A. Verify conditions and measurements affecting the work of this Section at site. Make sure that detrimental conditions are corrected before proceeding with installation.

3.2 INSTALLATION

A. Install materials in compliance with their manufacturer's instructions and the printed instructions of UL Fire Resistance Directory.

B. Install re-enterable, non-hardening, intumescent putty in workstation conduits where required. Do not use fire caulk.

3.3 IDENTIFICATION

A. Identify firestopping with pressure sensitive, self-adhesive preprinted labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestopping installation where the labels will be visible to anyone seeking to remove penetrating items or firestopping. Include the following information on the labels:
   1. The words: "WARNING—FIRESTOPPING—DO NOT DISTURB. NOTIFY BUILDING MANAGEMENT OF ANY DAMAGE”
   2. Contractor's name, address, and phone number
   3. Firestopping system designation of applicable testing and inspecting agency
   4. Date of installation
   5. Firestopping manufacturer's name
   6. Installer's name

END OF SECTION

SECTION 270543

UNDERGROUND DUCTS AND RACEWAY FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, and services to completely execute the provision of exterior telecommunications pathways as called for in these specifications and related drawings, including but not limited to:
   1. Cutting and Patching Asphalt and Concrete
   2. Trenching and Excavation
   3. Underground Conduit Systems
   4. Cable Routing Hardware
   5. Horizontal Directional Drilling – Also commonly referred to as Directional Boring or Guided Horizontal Boring

1.2 SYSTEM DESCRIPTION

A. Provide devices specified in this Section and related Sections for support of communications equipment specified for this project.

B. Feeder Duct-bank: Each building shall be fed from the nearest telecommunications maintenance hole via two (2) 4" PVC Schedule 40 conduits. Each PVC conduit shall include pull- rope. (Refer to the Telecom Site Plan for details).

C. Innerduct: Install three (3) - 3x3” multi-cell flexible innerduct into each of the 4” conduits. All pull cords shall be secured at each end to prevent accidental removal.

1.3 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS OR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

J. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

K. 271300 COMMUNICATIONS BACKBONE CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.4 SUBMITTALS

A. See Section 270500 – Common Work Results for Communications, for submittal procedures.

1.5 QUALITY ASSURANCE

A. All installation work for the new exterior telecommunications pathways shall be performed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated shall be subject to the control of Owner.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval based on submittals provided.

C. Materials and work specified herein shall comply with the applicable requirements of:
   1. California Electrical Code (CEC).
   2. IEEE/NESC – National Electrical Safety Code
   3. NEMA Standards including, but not limited to:
      a. NEMA, RN1, PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
      b. NEMA, TC3, PVC Fittings for use with Rigid PVC Conduit and Tubing.
      c. NEMA, TC6, PVC and ABS Plastic Utilities Duct for Underground Installation.
      d. NEMA, TC8, Extra Strength PVC Plastic Utilities Duct for Underground Installation.
      e. NEMA, TC9, Fitting for ABS and OVC Plastic Utilities Duct and Fittings for Underground Installation.
      f. NEMA, TC10, PVC and ABS Plastic Communications Duct and Fittings for Underground Installation.
   4. UL Standards including, but not limited to:
      a. UL 6, Rigid Metal Electrical Conduit
      b. UL 651 Schedule 40 and 80 PVC Conduit
   5. ANSI-C80.2, Specification for Rigid Steel Conduit, Enameled
   6. ANSI/TIA/EIA-569-E – Commercial Building Standard for Telecommunications Pathways and Spaces.
   7. ANSI/TIA/EIA-607-D – Commercial Building Grounding and Bonding Requirements for Telecommunications

8. ANSI/TIA/EIA-758-B – Customer Owned Outside Plant Telecommunications Cabling Standard (including all applicable addenda)
9. BICSI Telecommunications Distribution Methods Manual
10. BICSI Customer-Owned Outside Plant Manual

D. For horizontal directional drilling, the Contractor shall follow all procedural precautions necessary to ensure that the essential aspects of proper directional bore installation are adequately controlled.

E. Personnel for horizontal directional drilling shall be fully trained in safety and their respective duties as part of the directional drilling crew.

1.6 WARRANTY

A. See Section 27 05 00 – Common Work Results for Communications, for additional warranty requirements.

PART 2 - PRODUCTS

2.1 CONDUIT SYSTEM

A. Non-Metallic Conduit:
1. PVC plastic pipe, ASTM D1785, Schedule 40, Type PVC 1120.
2. Tone Tape, Arnco DL WP12LC Tone Tape, or equivalent.

B. Conduit Joint Couplings:
1. PVC non-metallic fittings must be installed with solvent applied couplings.
2. An approved transition coupling shall be used to connect metal to plastic (PVC) conduits.
3. Couplings may be threaded and / or glued to provide watertight seal at conduit junctions.

C. Electrical Metallic Tubing (EMT): Electro-galvanized steel tubing 3/4” and larger diameter per project requirements.
1. Conduit joint couplings and connectors: steel double set screw indenter fittings.
2. Metal bushings for 3/4” and 1” conduit.
3. Insulated metallic bushings for 1-1/4” and larger conduit.
4. Insulated metallic bushings with grounding lugs as required.
5. Conduit sweeps: minimum 10 times the conduit inside diameter.
6. Include required conduit straps, and hangers, heavy-duty malleable iron, or steel. Perforated pipe strap or wire hangers are not permitted.

D. Outside Pull-Box: Minimum 14-gauge galvanized steel with weatherproof locking cover and hardware for surface mounting as required for project. Dimensions as required for project.

E. Test mandrel shall be ¼” smaller than inside conduit diameter and not less than 12 inches long.

F. Pull-rope: 1/4” Nylon pull rope.

G. Core Drill Seals for Outside Building Walls: Link-Seal waterproof assembly or equal. Manufactured by PSI/Thunderline/Link-Seal.

H. Conduit Caulking Compound: Compounds for sealing conduit ducts shall have putty-like consistency workable with the hands at temperatures as low as 35 degrees Fahrenheit, shall not slump at a temperature of 300 degrees Fahrenheit, and shall not harden materially when exposed to the air. Compounds shall readily caulk or adhere to clean surfaces of plastic conduit, metallic conduits, or conduit coatings; concrete, masonry; any cable sheaths, jackets, covers, or insulation material, and the common metals. Compounds shall form a seal without dissolving, noticeable changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect on the hands of workers or upon materials.

I. Underground Plastic Line marker: Manufacturer's standard permanent, continuous-printed polyethylene film tape with metallic core, intended for direct burial service; not less than 3" wide x 4 mils thick. Provide orange tape with black printing reading, "CAUTION TELEPHONE/DATA CABLE BELOW," or similar.

J. Ground Wire: Bare Copper # 6

K. Tracer Box: NEMA-3 4" x 4" weatherproof box

L. Spacers for 4" Conduit: Carlon S289NJN Intermediate Spacer and S288NJN Base Spacer

M. Precast Concrete Vault:
   1. General: Provide precast concrete communications vault as detailed on the Drawings and as required for installation of new duct-bank systems and connection to existing duct-bank systems at locations shown on the Drawings. Provide 4'-0"x 5'-0" x 6'-0" deep precast.
      a. Design: Vaults shall be steel reinforced, and the complete vault assembly shall be designed for H-20-44 bridge loading. Submittals shall clearly indicate all dimensions and reinforcing steel.
   2. Concrete: Vaults shall be constructed using concrete with a 4500 psi 28-day strength. Concrete mix shall be designed in accordance with ASTM standards.
      a. Reinforcing Steel: Steel shall be intermediate or hard grade billet steel conforming to ASTM A15, deformed in accordance with ASTM A305.
   3. Vaults: Vault and pull box covers for all non-traffic areas shall be made of ductile iron cover, covers in parking and traffic areas shall be cast iron and rated for heavy vehicular traffic. Mount covers in a 30" Type "B" or "WRM" frame. The frame and neck shall be doweled into the vault to prevent movement away from the opening. Voice and Data communications vaults and pull box covers shall be marked "TELECOMMUNICATIONS".
   4. Conduit Entry: Plastic conduits shall include a bell end inside the vault or pull box, mounted flush and grouted to seal openings. Precast fiber type terminators shall be provided for each duct-bank entry.
      a. Grounding: A #4/0 bare copper ground wire shall penetrate the side wall in the bottom section of each vault and pull box and extend 48" inside and outside of the vault pull box.
   5. Accessories: Knockouts, cable racks, sumps, steps, joint seals, and other accessories shown on the Drawings or required for a complete installation shall be provided.

N. Duct Plug 4": General Machine Products (GMP) 6668R16

O. End Bell 4": Carlon E297N

P. Squeegee is moistened pea-sized gravel and sand mixture.

Q. Multi-cell Fabric Mesh Duct:
1. All fabric mesh duct shall be installed per manufacturer's requirements.
2. Only manufacturer's fittings, transition adapters, terminators, accessories, and installation kits shall be used.
3. All fabric mesh duct shall be populated with a measured pull tape.
4. Manufacturer: MaxCell.

2.2 CABLE ROUTING HARDWARE

A. Cable Rack with Support Hardware as Required (or comparable):
1. 18 Hole: Condux 08380200, Chance C203-1126
2. Other Sizes as Required: Condux, Chance

B. Cable Rack Steps/Hooks:
1. 4": Condux 08380600, Chance C203-1131
2. Other Sizes as Required: Condux, Chance

C. "S" Rack Supports: Condux, Chance

D. Step Lock Wedge: Panduit CHW-C20

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which the new exterior telecommunications pathways are to be installed. Provide notification, in writing, of conditions detrimental to proper completion of the work.

B. Verify field measurements and pathway routing conditions are as shown on drawings. Provide notification, in writing, of conditions deviating from drawings.

C. Beginning of telecommunications pathway installation indicates Contractor acceptance of existing conditions.

3.2 EXCAVATING, TRENCHING AND BACKFILLING

A. General: The work hereunder includes whatever excavating and backfilling is necessary to install the voice and data communications work. Coordinate the voice and data communications work with other work in the same area, including excavating and backfilling, dewatering, floor protection provisions, other temporary facilities, other underground services (existing and new),

landscape development, paving, structural foundations, and floor slabs on grade. Coordinate with weather conditions and provide temporary facilities needed for protection and proper performance of excavating and backfilling.

B. Standards: Except as otherwise indicated, comply with the applicable provisions for voice and data communications work excavating and backfilling. Refer instances of uncertainty to the Architect/ Engineer for resolution before proceeding with the Work.

C. Coordinate excavating, trenching, and backfilling with Landscaping, Civil, Mechanical, Plumbing and Electrical drawings. Voice and Data Communications duct-banks shall be independent of any other systems.

D. Refer to Civil contract documents for information regarding required depths, slope and grade and additional information regarding trenches. Where these documents and the civil documents differ, bring any such differences to the attention of the engineer prior to construction. The bottom of the trench shall be accurately excavated to provide firm, uniform bearing for the bottom of the raceways and duct-banks. Where mud or unstable soil is encountered in bottom of trench, it shall be removed to firm bearing and the trench shall be backfilled with bedding sand to proper grade and tamped to provide uniform firm support.

E. The bottom of trenches shall be accurately graded to provide proper fall and uniform bearing and support for each section of the conduit on undisturbed soil or 2" of sand fill at every point along its entire length. In general, grading for voice and data communications duct-banks and conduits shall be from building to vault, and from a high point between vaults to each vault.

F. Exercise care not to excavate below required depth, leaving a flat bed of undisturbed earth, firm and secure, before laying conduit. In the event rock is encountered, excavate 6" below required depth and backfill to required depth with bedding sand, and compact to minimum 95% compaction.

G. All grading in the vicinity of excavation shall be controlled to prevent surface ground water from flowing into the excavations. Any water accumulated in the excavations shall be removed by pumping or other acceptable method. During excavation, material suitable for backfilling shall be stacked in an orderly manner a sufficient distance back from edges of trenches to avoid overloading and prevent slides or cave-ins. Material unsuitable for backfilling shall be wasted and removed from the site and properly disposed of.

H. The Contractor shall be fully responsible for the safety of persons, materials, and equipment in or near trenches or other excavations and provide all required sloping, shoring, railings, and other protective provisions. The Contractor shall provide a trench shoring plan and design which is sealed by a registered professional engineer. Refer to Divisions 1 and 2 for additional requirements.

I. If any unknown and/or uncharted utilities are encountered during excavation, promptly notify Architect/ Engineer, and wait for his instructions before proceeding.

J. If such unknown utilities are encountered and work is continued without contacting the Architect/ Engineer for instructions, and damage is caused to said utilities, the Contractor shall repair at his own expense, such damage to the satisfaction of the owner or utility company concerned.

K. Trenches shall not be backfilled until all required tests have been made by the Contractor and approved by the Architect/Engineer and any local authorities having jurisdiction.

L. Backfill shall be cement stabilized sand up to 6" above the top of conduit or duct-bank as required by code. Backfill up to grade shall be in maximum 6" lifts with minimum 95% compaction of lifts. Refer to Division 2 or elsewhere in Contract Documents for additional trenching and backfill requirements.

M. Opening and Re-closing Pavement, Landscape Areas and Lawns: Where excavation requires the opening of existing walks, street, drives, other existing pavement or lawns, such surfaces shall be cut as required to install new conduit and to make new connections to existing conduits. The sizes of the cut shall be held to a minimum, consistent with the work to be accomplished. After the installation of the new work is completed and the excavation has been backfilled and flooded, the area shall be patched or replaced, using materials to match those cut out or removed. Patches shall thoroughly bond with the original surfaces, shall be level with them, and shall meet all the requirements established by the authorities having jurisdiction over such areas. All removed work shall be replaced by craftsman who regularly installs the types of work being replaced.

N. Excavation in Vicinity of Trees: All trees including low hanging limbs within the immediate area of construction shall be adequately protected to a height of at least 5’ to prevent damage from the construction operations and/or equipment. All excavation within the outermost limb radius of all trees shall be accomplished with extreme care. All roots located within this outermost limb radius shall be brought to the attention of the Architect before they are cut or damaged in any way. The Architect will give immediate instructions for the disposition of same. All stumps and roots encountered in the excavation, which are not within the outermost limb radius of existing trees, shall be cut back to a distance of not less than 18" from the outside of any concrete structure or pipeline. No chips, parts of stumps, or loose rock shall be left in the excavation. Where stumps and roots have been cut out of the excavation, clean compacted dry bank sand shall be backfilled and tamped.

O. Perform all trenching and backfill for new underground conduit system placement as shown on the project drawings.

P. Perform pavement marking as required. All utilities to be located by contractor and exposed, if necessary, prior to construction.

3.3 CONDUIT SYSTEM PLACEMENT

A. Place new conduit system including maintenance holes as shown on the project drawings.

B. Twelve-inch (12”) clearance from all utilities to be maintained. If not possible, conduit to be encased in concrete slurry (flow fill) where proper distance cannot be obtained.

C. Cross telecommunications conduit ducts below gas piping.

D. All conduits shall be thoroughly cleaned before laying or using.

E. During construction, the ends of the conduits shall be plugged to prevent water washing mud into the conduits, vaults, or buildings. Specific conduit care shall be taken to keep the conduits clean of concrete, dirt, or any other substance during the course of construction.

F. New and reopened trenches under asphalt roadways and parking lots must have concrete cap or be encased in concrete as required.

G. Support multiple conduits on preformed nonmetallic separators to provide not less than 1" spacing between exterior surfaces of conduit (Type 5). Spacing between separators shall be close enough to prevent sagging of conduits or breaking of couplings and watertight seals.

H. Squeegee is to be placed in the trench for 20' on each side of the vaults (Type 4).

I. Conduits shall be securely anchored in place with nylon tie-downs to prevent movement during the placement of concrete slurry (flow fill), squeegee, and other backfill materials. Wire tie-downs are prohibited.

J. Seal all conduit junctions and fittings watertight prior to pour of concrete slurry (flow fill). Conduit couplings shall be made in accordance with the manufacturer's recommendation for the particular type of conduit and coupling selected and as approved.

K. Unless otherwise noted on drawings, a minimum two-foot (24") depth of cover is required above the top of all conduits.

L. Provide communication drain box in conduit six feet (6') from building outside wall penetrations as shown in project drawings. Conduit inside drain box shall be perforated to allow water and gas to escape.

M. Transition to PVC coated GRC conduit five feet (5') from building outside wall penetrations.

N. For all offsets and sweep bends, provide fiberglass or PVC coated GRC.

O. All conduit bends are to be minimum 3' radius or larger as noted on drawings.

P. Bury underground plastic line marker one foot (12") above the telecommunications conduit.

Q. Cast into concrete a #6 bare copper ground wire directly above the telecommunications conduit and extend 4" into each vault space. Extend 6" of tracer wire into tracer box on outside wall of building directly above conduit entry point.

R. Provide plastic conduit bell ends at each PVC conduit termination and for all conduit entering vaults.

S. Do not bore under concrete sidewalks, remove, and replace sidewalks as necessary.

T. The new conduit shall extend through the wall into the building, tunnel, or crawl space a minimum of 4 inches.

U. Building, tunnel, and vault core drills must be sealed around conduits with approved waterproof plugging compound.

1. Seal openings around conduits that pass through inside building wall core drills with UL listed foamed silicone elastomeric compound.
2. Seal openings around conduits that pass through outside building walls with a complete Link-Seal assembly or equal for a waterproof seal. Slope conduit away from building.
3. Seal openings around conduits that pass-through vault walls with foundation foam on the interior of the core and silicone sealer on the inside and outside of the core for a waterproof seal.

V. Maintenance Holes (MH) shall be placed with the long dimension in line with the main conduit run. The conduit shall enter opposite ends of the MH on the short sides so that the MH shall not be used as a 90-degree bend in cable installations.

W. The ends of the metallic conduit shall be reamed and bushed using:
1. Insulated metallic bushings for 1-1/4" conduit and larger
2. Insulated metallic bushings with grounding lugs for conduit entering TRs and ERs

X. After conduit duct installation has been completed and concrete has set, pull "D" test mandrel through all new conduit ducts to verify duct integrity and ensure smooth interior surfaces free from burrs or obstructions that might damage cable sheaths.

Y. Following mandrel testing, draw cylindrical wire brush with stiff bristles through each conduit to clean the conduit and remove any concrete, dirt, or other obstructions.

Z. Stub out conduits into ERs, TRs, and cabinets only enough to attach connector and bushings with grounding lugs except conduits shall rise a minimum of 6 inches above the finished floor.

AA. Install new pull rope in all new conduit and extending three feet into each building space.

BB. Plug ends of the new conduit with watertight rubber conduit plugs, conduit caulking compound, or conduit caps to ensure foreign matter does not enter the buildings.

CC. Refer to Owner prior to cutting or drilling any surface.

3.4 CABLE ROUTING HARDWARE

A. Place new cable routing hardware in the tunnels and in crawl spaces beneath the building as required for the project and as shown on the drawings.

B. Perform installation of routing hardware as specified in Section 270526 including anchoring and supports, grounding and bonding, etc.

C. Place new ladder, pulling-in irons, cable racks, "S" rack supports, steps in new and existing vaults as required for backbone cable routing.

3.5 HORIZONTAL DIRECTIONAL DRILLING

A. Owner shall be notified 48 hours in advance of starting horizontal directional drilling work. The directional drilling shall not begin until Owner is present at the job site and agrees that proper preparations for the operation have been made.

B. No work shall commence until Traffic Control and Construction Permits from Owner and/or the City are in place as applicable for the specific project.

C. Site Preparation

1. Prior to any alterations to work site, the entry and exit points shall be marked.
2. No alterations to the work site beyond what are required for operations shall be made.
3. All activities shall be confined to designated work areas.

D. Drill Path Survey

1. The entire drill path shall be accurately surveyed with entry and exit stakes placed in the appropriate locations within the areas indicated on drawings.
2. If a magnetic guidance system is being used, the drill path will be surveyed for any surface geomagnetic variations or anomalies.

E. All applicable environmental regulations shall be adhered to.

F. Following drilling operations, the equipment will be de-mobilized, and the worksite restored to its original condition. All excavations will be backfilled and compacted to 95% of original density. Landscaping will be restored to original site conditions.

3.6 SAFETY

A. The contractor must comply with Owner regulations for asbestos, lead, and confined spaces.

B. All applicable state, federal and local safety regulations shall be adhered to, and all operations shall be conducted in a safe manner.

C. Guard vault openings per NESC C-2-2017, 423.A:

1. When covers of maintenance holes are removed, the opening shall be promptly protected with a barrier, temporary cover, or other suitable guard.

D. Test for gas in vaults and unventilated vaults per NESC C2-2017, 423.B and C, including, but not limited to:

1. The atmosphere shall be tested for combustible or flammable gases before entry.
2. Where combustible or flammable gases are detected, the work area shall be ventilated and made safe before entry.
3. Unless forced continuous ventilation is provided, a test shall also be made for oxygen deficiency.

4. Provision shall be made for adequate continuous supply of air. Note: The term adequate includes evaluation of both the quantity and quality of the air.
5. Employees shall not smoke in vaults.
6. Where open flames must be used in vaults or vaults, extra precautions shall be taken to ensure adequate ventilation.

3.7 AS-BUILT DRAWINGS

A. Mark the project drawings with notations reflecting any variations from the base specifications and drawings including as-built conduit routing.

END OF SECTION

SECTION 270553

IDENTIFICATION AND LABELING OF COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide all labor, materials, tools, and equipment required for permanent intelligible labeling for items including but not limited to communications cabling (structured and non-structured) innerduct, connectors, faceplates, jacks, receptacles, patch panels, and racks.

B. All labels will be preprinted, or computer printed type. Handwritten labels are not acceptable

C. This section includes minimum labeling requirements for the following:
   1. Room designations
   2. Communications cabling
   3. Closet Hardware including patch panels, terminal blocks, protectors, and racks
   4. Work Area Outlets
   5. Wireless Access Points
   6. Pathways and Spaces
   7. Grounding and Bonding

1.2 VISUAL APPEARANCE

A. Clear plastic covers over faceplate labels are not permitted.

B. Shall be preprinted or computer printed type.

C. Black SMBs are to be labeled with white on black.

D. Stainless will be labeled with black on white.

E. White (if required) will be labeled with black on white.

1.3 LABELING STANDARDS AND REQUIREMENTS

A. All new labeling is to reflect UCD labeling standards.

B. Contact the University's Representative for a copy of the current standards prior to proceeding.

C. Bring to the University Representative’s attention any project conditions not described in these specifications and the University's current standards and conform to the direction received.

D. Identification and administration work specified herein shall comply with the applicable requirements of:
   1. ANSI/TIA/EIA-606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

1.4 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

G. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

PART 2 - PRODUCTS

2.1 COMMUNICATION CABLING LABELS, GENERAL

A. Shall meet the legibility, defacement, exposure, and adhesion requirements of UL 969.

B. Shall be preprinted or computer printed type. Handwritten labels are not acceptable.

2.2 COMMUNICATION CABLING LABELS, INTERIOR

A. Provide vinyl substrate with a white printing area and black print.

B. If cable jacket is white, provide cable label with printing area which is either orange or yellow, such that the labels are easily distinguishable.

C. Shall be flexible vinyl or other substrates to apply easy and flex as cables are bent.

D. Shall use aggressive adhesives that stay attached even to the most difficult to adhere to jacketing.

E. Manufacturers:
1. Cable Type- 4 pair UTP /4 pair UTP Zero Skew - Panduit S100X125VAC or approved equal.
2. Cable Type- 4 pair STP - Panduit S100X125VAC or approved equal.
3. Cable Type- 25 to 100 pair copper - Panduit S100X650VAC or approved equal.
4. Cable Type- 2 strand fiber - Panduit F100X300AJT or approved equal.
5. Cable Type- 4-12 strand fiber - Panduit S100X125VAC or approved equal.
6. Cable Type- RG-6 and RG-59 Coax - Panduit S100X125VAC or approved equal.
7. Cable Bundles - Panduit UIHL12-XO or approved equal.
8. Other Interior Cabling - Panduit S100X650VAC or approved equal.

2.3 CLOSET HARDWARE LABELS

A. Shall meet the legibility, defacement, exposure, and adhesion requirements of UL 969.

B. Shall be preprinted or computer printed type. Handwritten labels are not acceptable.

C. Location ID:
1. Panduit - White C061X030FJC
2. Panduit - White C750XOSOYIJ
3. Or approved equal.

D. Non-keystone-based fiber patch panels:
1. Panduit - White C061X030FJC
2. Panduit - White C750XOSOYIJ
3. Or approved equal.

E. 110 blocks
1. Panduit C750XOSOYIC
2. Panduit S White C750XOSOYIJ
3. Or approved equal.

2.4 GROUNDING AND BONDING, PATHWAY, AND SPACE LABELS

A. Panduit C200X100FJC or approved equal.

2.5 WORKSTATION LABELS

A. Panduit - White C061X030FJC

B. Panduit - White C750X050YIJ or approved equal.

2.6 LOCATION NAMEPLATES

A. Provide laminated plastic nameplates for each equipment enclosure, rack, switch, and device, as specified.

B. Comply with ASTM D 709.

C. Each nameplate inscription shall identify the function and, when applicable, the position.

D. Nameplates shall be melamine plastic, 0.125-inch thick, black with white center core.

E. Surface shall be matte finish. Corners shall be square.

F. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by three inches.

G. Lettering shall be a minimum of 0.25-inch-high normal block style for location nameplates or a minimum of 1-inch-high normal block style for rack nameplates.

H. Panduit C300X100APT or approved equal.

2.7 COMMUNICATION CABLING LABELS, OUTSIDE PLANT

A. Cable Tags in Manholes, Handholes, and Vaults
   1. Provide tags for communications cable or wire located in manholes, handholes, and vaults.
      a. The tags shall be polyethylene.
      b. Machine printed - Do not provide handwritten letters.
   2. Polyethylene Cable Tags
      a. Provide tags of polyethylene that have an average tensile strength of 22.4 MPa (3250 pounds per square inch) 3250 pounds per square inch; and that are two millimeter (0.08 inch) 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C 170 degrees F.
      b. Provide 1.3 mm (0.05 inch) 0.05 inch (minimum) thick black polyethylene tag holder.
      c. Provide a one-piece nylon, self-locking tie at each end of the cable tag.
      d. Ties shall have a minimum loop tensile strength of 778.75 N (175 pounds) 175 pounds. The cable tags shall have black block letters, numbers, and symbols 25 mm (one inch) one inch high on a yellow background.
      e. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.
   3. Manufacturers:
      a. Panduit
      b. Brady
      c. Or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify all room numbers, racks, conduits, cable tray, cables, equipment housing, vaults and items within this document have been labeled.

B. Contractor applied labeling shall reflect final space and Telecommunications structure designations.

C. Accurate labeling shall be provided on the as-built shop drawing submittals.

3.2 IDENTIFICATION AND LABELING

A. Telecommunications Rooms
   1. Labels shall be affixed at the entry to all telecommunications rooms and spaces (Includes entrance facilities, telecommunications equipment rooms, communication equipment spaces and work areas).
   2. All IT rooms are numbered but not designated “equipment” due to security concerns.

B. Cable Tray and Conduits
   1. Cable tray structured versus AV or analog systems pathway labeling and designations are the responsibility of the installer to designate the services that are to use the pathway or what portion of the pathway.
   2. Any permanent label that is clearly visible is acceptable.

C. Rack and Cabinet Labeling
   1. Provide laminated plastic nameplates for each equipment enclosure, row and rack designations as shown on elevations provided by UCD IT.

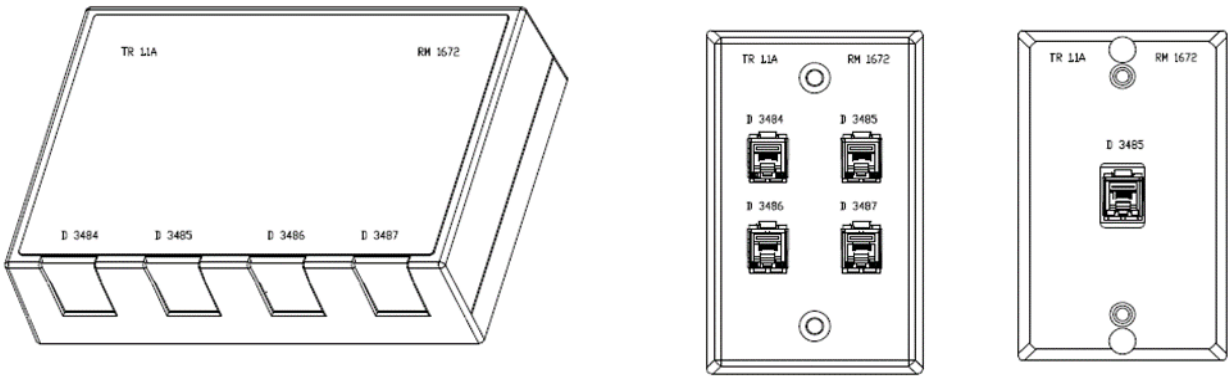
D. Copper Patch Panels – Horizontal
   1. Label with Jack numbers.

E. Tie Cable Patch Panels
   1. Label the pair count at the top of the patch panel, separated from all others.
   2. Place the cable's identification text centered on the top label strip. (Example:18CA75, TIE 1672A).

F. 110 Blocks
   1. Not used other than MPOE, OSP installation.
   2. Label with University provided designation.

G. Workstations
   1. Use adhesive type labels and affix labels to faceplate per diagram provided.
   2. Provide sequential 4 or (Occasionally 5 digit) jack number (starting dependent on the floor designation) beginning with an X such as X056, X being floor# followed by the closet sequenced cable number.

3. All faceplate labels shall contain the following items:
   a. Building and Closet Designation such as 34-1100 (building#, IT closet#)
   b. TR Designation such as TR1.1 or TR 1A (University established designation)
4. Under no circumstances are jacks to be installed with a drop/name or location number as a label or a matrix identifier.
5. See diagram below:



H. Wireless Access Point (WAP) Labeling
   1. The University's Representative will provide locations for Wireless Access Point installations with the University's assigned designated identifiers adhered to the Access Point itself.
   2. Building Designation / room or area designation – AP / a, b, c (if multiple APs within room).
   3. WAP labeling consists of the Icon being a designated color at the device, Icon being a designated color in the patch panel, and a band being installed on both ends of the patch cord that connects the cable in the TR room.

I. Grounding and Bonding
   1. Label the TMGB (telecommunications main ground busbar) with an adhesive label.
   2. Label the TGB(s) (telecommunications ground busbar) with an adhesive type of label(s).

J. Other Cable Numbering
   1. Other cabling types, such as Coax installed in a TR shall be numbered uniquely, such as C=Coax.
   2. Cameras and APs are Data Cabling, which falls into the Data Cabling labeling scheme.
   3. Point to point Data Cables require independent numbering such as A1001 for items such as in room video distribution such as N-stream equipment.

K. Fiber Patch Panels
   1. Fiber patch panels shall be marked using adhesive labels indicating the range of circuits installed to it. All fiber optic cable patch panels shall be labeled with the pair count of every fiber pair, the cable's assigned identifier, and the patch panel's assigned identifier.
   2. All labels shall consist of the following:
      a. Provide the respective FTU # next in sequence in the data room.
      b. Provide and label each bulkhead in the fiber panel per the following: Fiber Cable #, "FROM" Building / "FROM" Room / "FROM" FTU / Fiber Type / Strand # to

Location / Telecom Cable # / "TO" Building / "TO" Room / "TO" FTU / / Strand # / Fiber Type.

c. Coordinate with IT before applying any labels.

L. Fire stopping
1. Each fire stopping location shall be labeled at each location where fire stopping is installed, on each side of the penetrated fire barrier, within 12 in. of the fire stopping material.
2. Labels shall adhere to the requirements set forth by the authority having jurisdiction (AHJ).

M. Indoor Communications Cables
1. Horizontal and Indoor Backbone cables shall be marked within 12 inches of each endpoint or to innerduct in which the cable is installed.
2. Label each end of each riser cable where the cable terminates.
3. Backbone cables shall be marked at each endpoint and at all intermediate locations, pull/access point, or junction boxes through which the cable passes, as well as on each floor and in each room the cable is openly visible in.

N. Copper Riser Cabling.
1. Label all copper backbone cables of at least 25 pair constructions to contain the following information:
   a. Installation Date
   b. University Assigned Cable ID: (Example: 70 Tie 0P609).

O. Fiber Riser cabling.
1. Label all fiber backbone cables to contain the following information:
   a. Installation Date
   b. University Assigned cable ID:(Example: IFA134)

END OF SECTION

SECTION 271116

COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Equipment racks shall be Owner furnished; Contractor installed.

B. The Owner standard is to provide 3 feet clearance from all rack and rack hardware to other hard surfaces in addition to allowing for code requirements for electrical power in the room. Some instances may require deviations due to room sizes and architectural features. Install racks according to construction documents. Report conflicts to IT before installation.

1.2 PREPARATION

A. Verify that no mechanical, electrical, or other systems and piping systems, (e.g., water sources) run through the TR Rooms or IT spaces

B. Receive approved layout from Owner IT.

C. Validate the package for the IT installation, e.g., power for equipment, pathway for cabling air conditioning and incidentals for proper operation of each TR.

1.3 EQUIPMENT MOUNTING

A. All floor supported equipment racks shall be bolted to the structure in accordance with the requirements of the CBC.

B. Contractor shall install per approved structural engineering design illustrating the materials approved that conform to these requirements.

1.4 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Not used.

PART 3 - EXECUTION

3.1 GENERAL

A. Free-standing Universal Racks
1. Assemble relay racks according to manufacturer's instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.
2. Racks and cabinets must be attached to the floor in four places using appropriate floor mounting anchors. When placed over a raised floor, threaded rods should pass through the raised floor tile and be secured in the structural floor below.
3. Racks and cabinets shall be grounded to the TGB and or TMGB using appropriate hardware provided by the contractor. The ground will meet local code requirements and will be approved by the Authority Having Jurisdiction (AHJ).
4. In seismic areas, the rack should have additional bracing as required by building codes and the recommendations of a licensed structural engineer.
5. Ladder rack may be attached to the top of the rack to deliver cables to the rack. The rack should not be drilled to attach ladder rack. Use appropriate hardware from the ladder rack manufacturer.
6. The equipment load should be evenly distributed and uniform on the rack. Place large and heavy equipment towards the bottom of the rack. Secure all equipment to the rack with equipment mounting screws.
7. Install per approved structural requirements as defined by the project structural review.

END OF SECTION

SECTION 271119

COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install copper termination assemblies, including rack and cabinet mounted copper patch panels.

B. Furnish and install fiber termination assemblies, including:
   1. Fiber connectors
   2. Rack and cabinet mounted fiber patch panels

1.2 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

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L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.3 SUBMITTALS

A. Provide product data for the following:

1. Manufacturer's data/cut sheets, product drawing/specifications and installation instructions for all products (submit with bid).

1.4 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the owner or owner representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated or a substitution is requested, equipment shall be equivalent in every way to that of the equipment specified. All substitutions are subject to the control and approval of the owner or the owner representative.

C. Strictly adhere to all BICSI, and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

1.5 WARRANTY

A. The horizontal communications cabling system installed shall be eligible for coverage by a Limited Lifetime Warranty to the end user.

B. Authorized Installer/Authorized Integrator shall provide labor, materials, and documentation in accordance with Panduit requirements necessary to ensure that the Owner will be furnished with a Limited Lifetime Warranty.

C. Necessary documentation for warranty registration shall be provided to the manufacturer by the installer (within 10 days) following 100 percent testing of cables.

PART 2 - PRODUCTS

2.1 COPPER CABLE TERMINATION DEVICES AND RELATED

A. Copper patch panels
   1. Rack mount category 6A 8P8C
   2. Panduit CP48WSBLY
   3. Or approved equal.

2.2 FIBER CABLE TERMINATION

A. Fiber Optic Connectors
   1. Connectors are fusion splice termination style.
   2. Provide fusion splice to factory assembly including fiber pig tail & connector
   3. Insertion loss for multi-mode ≤ 0.03 dB - manufacturer's rating for typical splice.
   4. Insertion loss for single mode ≤ 0.06 dB - manufacturer's rating for typical splice.
   5. LC at rack mounted patch panels as noted or scheduled,

6. Use Corning Cable Systems model X77 Micro Fusion Splicer, Fujikura fusion splicer, or equal.

B. Utilize a precision zirconia ceramic ferrule.

C. Shall have a radial-ramped coupling nut, which facilitates mating/de-mating.

D. Connector performance per TIA-568. C.3 and the following:
1. Insertion Loss, multimode: Less than or equal to 0.75 dB per mated pair.
2. Insertion Loss, single mode: Less than or equal to 0.50 dB per mated pair
3. Insertion Loss: single mode, angle polish: Less than or equal to 0.30 dB per mated pair
4. Return Loss: single mode, Ultra Polish, greater than or equal to 55 dB
5. Return Loss: single mode, Angle Polish, greater than or equal to 65 dB

E. Fusion Spliced LC Multimode matching to the fiber type being terminated.

F. Fusion Spliced LC Single Mode matching the fiber type being terminated.

2.3 FIBER DISTRIBUTION PANELS

A. Fiber Termination Unit
1. AFL rack mounted fiber housing with LC connector panels sized accordingly.
2. Provide manufacturer's blank cover inserts at unused openings.

PART 3 - EXECUTION

3.1 GENERAL

A. The contractor selected to provide the installation of this system shall be certified by the manufacturing company in all aspects of design, installation and testing of the products described herein.

B. Contractor shall have a minimum of five (5) years of recent experience on structured cabling systems of similar type, size, and quantities.

C. Cable termination:
1. Route cables in Telecom Rooms to patch panels in racks by routing across cable runway to top of rack and then down vertical cable management sections to back of patch panels or termination locations.
2. Route cables in Telecom Rooms to wall mount cabinets and down through openings of top and/or bottom of cabinets to patch panels. Cabinet standoffs may be used to create additional and necessary pathway.
3. Cables and Termination Hardware: Test 100 percent for defects in installation and verify cabling system performance under installed conditions.
a. Verify all pairs of each installed cable before system acceptance.
b. Defects in cabling system installation, including but not limited to cables, connectors, patch panels, and connector blocks shall be repaired or replaced to ensure 100 percent useable conductors in all cables installed.

4. Cables, Jacks, Connecting Blocks, and Patch Panels:
   a. Verify all pairs of each installed cable before system acceptance.
   b. Defects in cabling system installation, including but not limited to cables, connectors, patch panels, and connector blocks shall be repaired or replaced to ensure 100 percent useable conductors in all cables installed.

END OF SECTION

SECTION 271123

COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes provision of cable management for cabling installed under the work of this Project.

B. Install plywood to surround each TR room to support systems and cable management.

C. Install ladder racking.

D. Install Owner provided racks and vertical wire managers to support cable management and supporting systems within the room.

E. Contractor to furnish and install patch panels.

F. Contractor to furnish and horizontal cable management.

G. Install conduit, fire penetrations, and cable pathway suitable to support and manage the installation of fiber and copper data infrastructure per BICSI standards.

H. Ensure proper maximum fill ratios for all pathways. Do not overfill pathways.

I. Ensure proper EMI separation.

J. Install innerduct where required.

1.2 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

PART 2 - PRODUCTS

2.1 BACKBOARD CABLE MANAGEMENT (CONTRACTOR FURNISHED AND INSTALLED)

A. ¾ inch x 48" x 84 "A/C grade, fire rated, painted plywood installed on perimeter of the room.
   1. Plywood will be painted with an approved fire-retardant paint compliant with APWA and CSFM/CBC standards.
   2. Fire rating labels on plywood will be covered with masking tape before painting and later removed to allow for inspection before turnover.

2.2 INNERDUCT (CONTRACTOR FURNISHED AND INSTALLED)

A. Interior (non-plenum)
   1. Carlon Optic-Gard/PVC.
   2. Arnco.

B. Interior (plenum)
   1. Carlon Plenum-Gard.
   2. Arnco.

2.3 CONDUIT SPILLWAY (CONTRACTOR FURNISHED AND INSTALLED)

A. For conduit transitions.

B. Constructed of fire-retardant ABS.
   1. Panduit CWF400 or equal.

2.4 CABLE TRAY WATERFALL (CONTRACTOR FURNISHED AND INSTALLED)

A. Provide cable tray waterfall or drop out at ends of all runs.
   1. Cooper B-line 9A-1104.
   2. Cooper B-line 99-1124.
   3. Or approved equal.

2.5 CABLE TRAY TRANSITIONS (CONTRACTOR FURNISHED AND INSTALLED)

A. All turns, bends, and direction changes shall use manufacturer's pre-manufactured materials.

B. Vented trough engineered rounded transitions such as Cooper B-line 4AVT-12-90-HB-24 shall be accepted.

2.6 CABLE TRAY DIVIDER (CONTRACTOR FURNISHED AND INSTALLED)

A. Provide where separation is required between conductors routed in the same tray.
1. 73A-90HBFL.
2. Or approved equal.

2.7 BASKET TRAY WATERFALL (CONTRACTOR FURNISHED AND INSTALLED)

A. Provide cable tray water fall at all trays ends and side cuts.

B. Provide drop out at center cuts.
1. Panduit WGBTMWFBL.
2. Panduit WGSDWWF4BL.
3. B-line WB06-DO (8 or 12).

2.8 BASKET TRAY RAIL RISER (CONTRACTOR FURNISHED AND INSTALLED)

A. WB2RR or equal.

2.9 BASKET TRAY DIVIDER (CONTRACTOR FURNISHED AND INSTALLED)

A. WB2B-3M or equal.

2.10 J HOOK CABLE MANAGEMENT (CONTRACTOR FURNISHED AND INSTALLED)

A. Provide and install according to Section 27 05 29.

2.11 HORIZONTAL WIRE MANAGER (CONTRACTOR FURNISHED AND INSTALLED)

A. Install 2 or 4 RU assembly as indicated in Owner provided rack elevations.

B. Panduit NM2 or NMF4 as shown on IT rack elevation drawings.

2.12 VERTICAL WIRE MANAGEMENT (OWNER FURNISHED AND CONTRACTOR INSTALLED)

A. High density vertical wire manager to accommodate fiber and copper cross connecting patching cables in addition to providing power distribution power strip mounting surfaces and space.

B. Owner provided; Contractor installed; refer to Owner provided rack elevation drawings.

1. Install according to construction documents.

PART 3 - EXECUTION

3.1 GENERAL EXECUTION - PREPARATION

A. OWNER IT is responsible for preliminary layout of the telecommunications room and shall provide requirements to Construction Team for the production of shop drawings.

B. The cabling contractor in addition to the engineer is responsible for managing cable quantities and validation of the pathways provided for fill ratio and placement to ensure cable length and capacities are according to Owner requirements. If a determination is made that the pathway is deficient, the contractor shall construct additional pathways accordingly.

C. Install products, components, accessories, hardware, etc., according to the manufacturer's instructions.

D. The contractor selected to provide the installation of this system shall be certified by the manufacturing company in all aspects of design, installation and testing of the products described herein.

3.2 PATHWAY CABLE MANAGEMENT

A. Provide a comprehensive cable management system complete with all accessories including radius corners at vertical and horizontal bends, section splice plates, expansion plates, blind-end plates, etc.

B. Cable Tray/Basket Tray Cable Management
   1. Do NOT Tie Wrap cables.
   2. Do NOT Secure cables to cable tray unless required to hold in place.
      a. Cable shall not be attached to the cable tray (i.e., cable shall be left "loose")
   3. For performance reasons, station cabling in tray shall not be combed.
   4. Cable shall be laid in tray or ladder rack in such a way as to present a neat and professional appearance.

C. Ladder Rack Cable Management
   1. Do NOT Tie Wrap cables.
   2. Do NOT Secure cables to cable tray unless required to hold in place.
      a. Cable shall not be attached to the cable tray (i.e., cable shall be left "loose").
   3. For performance reasons, station cabling in tray shall not be combed.
   4. Cable shall be laid in tray or ladder rack in such a way as to present a neat and professional appearance.

D. J HOOK Cable Management
   1. Cables are to be consistently grouped together with like systems cabling (Fiber/AV/ Copper/Feeder, Etc.
   2. Suspended cable runs (J-Hooks) shall be supported at intervals not exceeding every 5'. Cable installed on exposed surfaces or structural members shall be installed parallel and

perpendicular to the surfaces unless a cable distance limitation arises. Cable distance and remaining within cable distance limits shall take priority. Surface contours shall be followed wherever possible.

3. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system (grids, hanger wires, etc. – with the exception of ceiling support anchors) is not acceptable unless approved by the AHJ
4. Cabling installed in J-Hooks or Stiffy's, shall not have a deflection of more than 3", as identified in the cable support details, in the drawings.

3.3 EXAMINATION AND ACCEPTANCE

A. Perform walk thru with Owner representative to validate cable separation, cable routes and fill ratios.

END OF SECTION

SECTION 271126

COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Building IT UPS. Three phases.
   1. All IT equipment in the IT room shall be serviced (unless prohibited by code) by the IT UPS. A single efficient building UPS is the goal of IT to minimize UPS size and optimize maintenance. (Owner Furnished, Owner Installed)

B. Single phase IT UPS systems up to 10 KVA (Owner Furnished, Owner Installed)

C. IT UPS systems larger than 10 KVA, or three phase unit, Owner Furnished Contractor Installed.

D. Power provided to the IT UPS system, contractor furnished, and contractor installed.

E. Power Distribution from IT UPS power distribution panel to each outlet, Contractor Furnished and Contractor Installed.

F. Turn up, test and certification provided by Owner.

G. Installation of Power Strips in Cabinets and Racks are Owner Furnished Owner Installed.

1.2 REFERENCES

A. ANSI/TIA-569-E Telecommunications Pathways and Spaces, 2019

B. ANSI/TIA-568.0-D Generic Telecommunications Cabling for Customer Premises, 2015

C. ANSI/TIA – 568.1-D Commercial Building Telecommunications Cabling Standard, 2015.

D. ANSI/TIA-942-B Telecommunications Infrastructure Standard for Data Centers, 2017.

E. ANSI/TIA – 606-C Administration Standard for Telecommunications Infrastructure, 2017.

F. ANSI/TIA – 607-D Generic Telecommunications Bonding and Grounding (Earthing) For Customer Premises, 2019.

G. ANSI/TIA-862-B Structured Cabling Infrastructure Standard for Intelligent Building Systems, 2016

H. California Electrical Code (CEC).

1.3 SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for rack-mounted power protection and power strips.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include workspace requirements and access for cable connections.
   3. Grounding: Indicate any chassis bonding requirements.
   4. Network Connection and Programming: Indicate networking and configuration requirements and connections.

1.4 QUALITY ASSURANCE

A. Product Certifications: UL & cUL 62368; IEC 62368; CE; FCC Part 15, Class A; EN 55022 and RoHS Compliant

1.5 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

J. 271300 COMMUNICATIONS BACKBONE CABLING

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.6 SEQUENCING

A. Coordinate with Construction management and Owner representative. A 30-Day burn in is required for electronic equipment.

1.7 PREPARATION

A. Verify that no piping systems, (e.g., water sources) run through or above the UPS location.

B. Provide shop drawings indicating locations and sizes of UPS systems to receive approval of IT Facilities.

1.8 EMERGENCY POWER

A. Provide two (2) separate emergency distribution systems from two (2) ATS designed "Life Safety System" and "Equipment System" where available.

1.9 POWER NON-HOSPITAL (LEASED ADMIN)

A. Provide two (2) separate distribution systems from two diverse panels.

B. Where available backup generator service shall provide service to UPS equipment.

C. Owner required emergency power loads such as IT systems shall be placed on the "Equipment System" (Load shedding provisions).

PART 2 - PRODUCTS

2.1 UNINTERRUPTABLE POWER SUPPLIES

A. Liebert UPS

2.2 GENERAL

A. A bypass circuit shall be provided as an integral part of the UPS. The bypass control logic shall contain an automatic transfer control circuit that senses the status of the inverter logic signals and operating and alarms conditions. This control circuit shall provide a transfer of the load to the bypass source if available and if the inverter is capable of powering the load (i.e., if there is an overload condition, if the unit is in Manual Bypass Mode or if the voltage or frequency is out of tolerance).
   1. Automatic Transfers

2.3 BYPASS

A. The transfer control logic shall activate the bypass automatically, transferring the critical AC load to the bypass source, shall be provided when applicable.

B. COMMUNICATION OPTIONS
   1. Liebert IntelliSlot Communications

C. The UPS shall include one Liebert IntelliSlot communication port to allow the operator to field-install an optional Liebert IntelliSlot communication card. A Liebert IntelliSlot card may be installed during any state of UPS operation (On, Standby or Off states). Available Liebert IntelliSlot options are described below.

D. Liebert IntelliSlot Web Card (IS-WEBCARD)

E. The optional Liebert IntelliSlot Web Card shall deliver SNMP and Web management to the UPS when connected to any 10 or 100 Mbit Ethernet network. The card shall support 10 and 100 Mbit Ethernet and shall provide for in-the-field upgrade of SNMP firmware. The kit shall include the Liebert IntelliSlot card, MIB, configuration cable and user manual.

F. Liebert IntelliSlot Relay Interface Card (RELAYCARD-INT)

G. The optional Liebert IntelliSlot Relay Interface Card shall provide contact closure for remote monitoring of alarm conditions in the UPS, delivering signals for On Battery, On Bypass, Low Battery, Summary Alarm, UPS Fault and on UPS. The contacts shall be rated for 24VAC or 24VDC at 1A. Connections shall be to a DB25F connector with cable provided by the end user.

2.4 ANY-MODE SHUTDOWN

A. The purpose of Any-Mode Shutdown shall be to shut down the UPS output by turning off the rectifier, inverter, and bypass so that there is no power to the loads.

B. Any-Mode Shutdown can be operated locally and remotely, as described as follows:

C. Local Any-Mode Shutdown can be performed by shorting Pin 1 and Pin 2

D. Remote Any-Mode Shutdown can be performed by a switch connected to Pin 1 and Pin 2 and mounted at a remote location.

E. Remote Power Off shall be performed either by NO or NC contact of Any-Mode Shutdown, depending on the settings in the configuration program.

F. A current-limited source (+12VDC, 50mA) shall be available from the UPS.

G. The connection to the UPS for remote connection shall be via terminal block connector.

H. Any-Mode Shutdown wiring shall conform to all national, regional, and local wiring regulations.

2.5 BATTERY MODE SHUTDOWN

A. Battery Mode Shutdown shall permit shutting down the UPS by turning Off the rectifier, inverter, and bypass so that there is no power to the load when the UPS is On Battery. Battery Mode Shutdown can be performed locally or remotely:

B. Local Any-Mode Shutdown can be performed by shorting Pin 3 and Pin 4.

C. Remote Any-Mode Shutdown can be achieved by a switch connected to Pin 3 and Pin 4 and mounted at a remote location.

D. On Battery

E. On Battery signal shall be a normally open (NO) dry contact. When the UPS is supplying output power from the battery this dry contact shall be closed.

F. Low Battery

G. Low Battery signal shall be a normally open (NO) dry contact. When the UPS is supplying output power from the battery and has reached the Low Battery Warning time selected in the configuration program, this dry contact shall be closed.

H. The rated values for the dry contacts shall be:

I. Rated Voltage: 5V

J. Working Voltage Range: 4.5-10V

K. Rated Current: 30Ma

2.6 LIEBERT REMOTE SYSTEMS MONITORING

A. All UPS systems must integrate into the existing UPS remove monitoring system to be approved for installation.

2.7 WARRANTIES

A. Minimum of 3 years of standard warranty with ability to extend by at least 2 additional years. Advanced replacement of defective equipment shall be offered as a standard service.

PART 3 - EXECUTION

3.1 GENERAL

A. Confirm the exact power output distribution requirements with the Owner's Representative.

B. Estimated runtime of 30 minutes is required. Provide Quantity (2) Two Optional External Battery Cabinets in base bid. Check with Owner’s Representative for additional requirements.

C. Secure approval of UPS locations with IT Facilities.

D. Confirm the location of Power Strips with the Owner's Representative. (1) One Power Strip per Vertical Wire Manager is required.
   1. Three Rack Layout requires (4) Four Vertical Power Strips, (1) One Horizontal Power Strip

2. Four Rack Layout requires (5) Five Vertical Power Strips, (2) Two Horizontal Power Strips

E. Input Disconnect
1. Install disconnect to input of UPS applicable to the size and type of appliance.
2. 10 KVA UPS installations shall have a wall mounted disconnect (EPO) within the IT Equipment room.
3. 6 KVA UPS installations shall have a wall mounted disconnect (EPO) within the IT Equipment room.
4. 3 KVA Disconnect or EPO is provided within the UPS itself.

F. Demonstration
1. Full functionality of UPS by:
   a. Disconnecting power to the UPS and demonstrating ability of UPS to carry load consistent with the manufacturers' runtime for the attached load.
   b. Demonstrate that the UPS passes the manufacturers diagnostic software with no errors.

END OF SECTION

SECTION 271300

COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. The Section applies to all new TR rooms within the project. Work of this Section includes:
   1. Indoor Copper Backbone Cabling between Telecommunications Rooms.
   2. Indoor Copper Backbone Cabling between Telecommunications Rooms and MPOE.
   3. Indoor Optical Fiber Backbone Cabling between Telecommunications Rooms.

1.2 SYSTEM DESCRIPTION

A. High-capacity infrastructure required to support aggregated voice and data communications to areas outside the immediate influence of the local TR Room.

B. Communications Back Bone typically consisting of:
   1. Category 3 Voice Grade Copper Communications Infrastructure Backbone
   2. Optical Fiber Transport Medium(s) Infrastructure Backbone

C. This section may describe configurations for cabling associate with the Owner Medical Center Campus. Offsite configuration may require circuit extensions and single entrances not described in the specification. Report conflicts between construction drawings and IT standard to the Owner representative before purchasing material or proceeding with installation.

1.3 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

J. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

K. 271343 COMMUNICATIONS SERVICES CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, AND ANTENNA SYSTEMS

1.4 SUBMITTALS

A. Provide submittal information for the following submittal sections as described below:
   1. Product Data
   2. Shop Drawings:
      a. Cable routing and Grouping Plan.
      b. Front of Rack elevations showing completed as-built corrections.
      c. Provide as-built records of equipment cabinet/rack with addressing and labeling scheme.
      d. Provide as-built fiber strand, adapter panel, and FDU and WME housing addressing, and labeling scheme as installed.

PART 2 - PRODUCTS

2.1 CATEGORY 3 RISER / HORIZONTAL BACKBONE CABLING

A. Shall be EIA/TIA Category 3 cable

B. Each conductor shall be a minimum of 24 AWG

C. Plenum Rated (CMP) Solid conductor 100-ohm multipair UTP (Unshielded twisted pair), formed into 25 pair binder groups.

D. Imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular intervals not to exceed 2'.

E. The word "FEET" or the abbreviation "FT" shall appear after each length marking.

F. Provide Telecommunications plenum (CMP) rated cabling for horizontal and cables designated as riser cable.

G. Manufacturer:
   1. General Cable
   2. Or approved equal.

2.2 FIBER OPTIC COMMUNICATIONS CABLING

A. Fiber Optic Cable, Inside Distribution, Breakout Cable
   1. Manufacturer: General Cable BEXXX1PNU-ILPA and APXXX1PNU-ILPA (where "XXX" equals strand count)
   2. Or AFL .

B. Fiber Optic Cable, Plenum
   1. General Cable BEXXX1PNU-ILPA and APXXX1PNU-ILPA, where XXX equals strand count.
   2. Or AFL CRXXX9891#01-AIAR .

PART 3 - EXECUTION

3.1 GENERAL

A. All system cabling and terminations shall be installed in accordance with manufacturer's instructions and as indicated on Contractor's submittal documentation, prior to final acceptance/approval by the Owner.

B. Installation shall be performed and accomplished in a professional manner, by qualified personnel.

3.2 PERFORMANCE STANDARDS

A. Telephone (Voice) Copper Cabling Plant
   1. Suitable for direct connection to the public switched network in accordance with rules set forth by FCC Part 68, California Public Utilities Commission, and other authorities having jurisdiction.
   2. Category 3 as defined in TIA-568-C.2

B. Fiber Optic Cabling
   1. The optical loss budget for any end-to-end link not to exceed the sum of (optical fiber loss + splice loss + connector loss).
   2. Optical fiber loss shall be the optical fiber specified cable performance, pro-rated for total link distance.
   3. Fiber loss, multimode, not to exceed:
      a. At 850 nanometers, 3.5 dB per kilometer; at 1300 nanometers, 1.5 dB per kilometer.
   4. Fiber loss, single mode, outside plant cable, not to exceed:
      a. At 1310 nanometers, 0.5 dB per kilometer; at 1550 nanometers, 0.5 dB per kilometer.
   5. Fiber loss, single mode, inside plant cable, not to exceed:
      a. At 1310 nanometers, 1.0 dB per kilometer; at 1550 nanometers, 1.0 dB per kilometer.
   6. Splice loss, multimode not to exceed 0.15 dB for each fusion splice.
   7. Splice loss, single mode not to exceed 0.06 dB for each fusion splice.
   8. Connector loss, multimode not to exceed 0.75 dB for each mated pair of type lc, ultra-polish connector.
   9. Connector loss, single mode not to exceed 0.60 dB for each mated pair of type lc, ultra-polish connector or 0.30 dB for each mated pair of type lc, angle polished connector.

3.3 INSTALLATION

A. CAT3 COPPER BACKBONE CABLE
   1. Application for TR / MPOE / EF CAT3 Interconnectivity Copper Backbone.

2. Minimum configuration of CAT3 Interconnectivity between MPOE and all telecommunications TR rooms shall be a 50 Pair, to each TR.

B. FIBER OPTIC CABLING
1. Minimum Interconnectivity between MPOE and all TRs shall be 24 strand SM fiber, to each TR.
2. Interconnectivity from the secondary EF to all other TR's shall be 24 strand SM fiber, to each TR.
3. Diverse physical pathway shall be determined between telecommunications rooms that precludes using a single physical pathway for all backbone cabling between TR's.
4. At TR / MPOE and EFs, at both ends of cables, wrap the room before entering patch panel by a dressed route.
5. At interior: Provide splice free cabling between telecom rooms; as well as between telecom rooms and all locations in the same building indicated for fiber cabling media.
6. Terminate fibers using a pre-terminated LC connector were indicated by Owner Representative.
7. Review proposed breakout procedure with the Owner's Representative before beginning this work.
8. Refer to OWNER IT elevations and distribution drawings for further details.

3.4 TESTING

A. GENERAL
1. Test and report on each intermediate cabling segment separately, including station cabling, horizontal distribution (each segment, if multiple) and telecommunications room wiring.
2. Test each end-to-end cable link.
3. Submit machine-generated documentation and raw data of all test results on Contractor-provided, and Owner's representative approved, forms; and in electronic format approved by the Owner's Representative.

3.5 TEST PROCEDURES – COPPER
1. A new cable shall be tested only after all wires within the cable have been terminated at both ends.
2. The Contractor shall test all high-count copper cables and submit test result information in an electronic format. Acceptable formats are Word, Excel. Owner's representative to provide required format for test report documentation.
3. TEST #1 – Continuity: Use multi-meter capable of reading resistance.
4. Meter set for 20-ohm full scale ohm reading. Each pair shall be shorted at one end and the loop resistance value read at the other.
5. The difference between the largest and the smallest resistance reading from each pair in the cable shall be no more than 10 percent of the largest reading.
6. TEST #2 - Balance, Polarity and Conductor Transpositions:
7. Upon passing Test #1, the tester at one end of cable shall ground tip side of each pair in turn. The tester at other end of cable reads resistance to building ground of same conductor.
8. REQUIREMENT: Reading for each tip conductor in pair of approximately one-half the loop resistance value from Test #1.
9. The Contractor shall correct all defects possible.

10. If the maximum number of unrepairable defective pairs exceeds 1% of the cable's pair count, the cable shall be deemed unacceptable and shall be replaced. Replace, re-terminate and retest new cable at no additional cost to the Owner.
11. Comply with the detailed reporting results described above and the following: high pair count copper cables.
12. Submit Test Report. Documentation shall include loop resistance regarding any opens, shorts, transpositions found, as well as corrective action taken to correct any found opens, shorts, or transpositions.

3.6 TEST PROCEDURES – FIBER

A. Testing
1. The Contractor shall test all fiber optic cables and submit all fiber test result data in electronic format.
2. Perform fiber optic cable testing on all installed fiber optic cabling. Submit test results. Notify Owner's representative in writing at least 72 hours in advance that fiber optic cable testing shall commence. Submit calibration certification for testing equipment to be used.
3. A new cable shall be tested only after all wires within the cable have been terminated at both ends unless specifically requested by the Owner.
4. Fibers tests shall include OTDR, results with the meter set to the wavelength measurements specific to the cable or as requested by IT.
5. A second set of testing shall be power meter for the same strands
6. OTDR Distance and Attenuation Assessments perform on all cabling segments perform in accordance with the requirements of: TIA-568-C.1, TIA-568-C.3, TIA-455-59-A.
7. Test all fibers with launch and far end cable of sufficient length for the OTDR to be able transmit through all installed connectors.
8. OTDR through all connectors, a one-way test is not acceptable. Means and methods to fully evaluate product installed shall be approved prior to commencing.
9. Test and submit strip charts and/or tracer recordings on all strands in each tube in every cable in both directions.
10. User Interface records including a graph depicting fiber loss locations and total DB loss per event via OTDR.
11. Submit test report no later than five days after the cables are tested.

B. Test and submit OTDR attenuation assessments test results on each fiber, in each cable, and in both directions under final installation conditions. Submit with the following information:
1. Date of test
2. Name of test personnel
3. Test wavelength
4. Pulse duration(s) and scale range(s)
5. Index of refraction
6. Fiber cable type and part number
7. Fiber tube and/or fiber strand number
8. Direction of test
9. Overall distance
10. Attenuation in dB
11. Localized attenuation shall not exceed 0.5 dB at any point

3.7 TEST EQUIPMENT

A. Contractor shall provide all test equipment as required to perform the scope of work.

B. Test the communication systems cabling using at least one (1) each of the following test measurement devices or their functional equivalents:
   1. Level III field testers as defined in TIA-1152 – Fluke DSX-5000, or equal.
   2. The tester including the appropriate interface adapter must meet the specified accuracy requirements.
   3. The accuracy requirements for the permanent link test configuration (baseline accuracy plus adapter contribution) are specified in Table 4 of TIA-1152.
   4. The RJ45 test plug shall fall within the values specified in TIA-568-C Annex C for NEXT, FEXT and Return Loss.
   5. The tester interface adapters must be of high quality and the cable shall not show any twisting or kinking resulting from coiling and storing of the tester interface adapters.
   6. In order to deliver optimum accuracy, permanent link interface adapter for the tester shall be used, which can be calibrated to extend the reference plane of the Return Loss measurement to the permanent link interface. The contractor shall provide proof that the interface has been calibrated within the period recommended by the vendor.
   7. To ensure that normal handling on the job does not cause measurable Return Loss change, the adapter cord cable shall not be of twisted-pair construction.
   8. Outside Plant Voice Cabling Plant tester - capable of detecting shorts, opens, reversals, mis-wiring and cross twists.
      a. Siemon STM-8, Fluke or equal.

C. Optical Power Meter - Multimode
   1. Corning Cable Systems, Fluke or equal
   2. Minimum Performance - Multimode Power Meter 850nm and 1300nm +/- 20 nm wavelength LED light sources.
   3. Spectral width of sources shall be </= 50nm for 850nm wavelengths and </= 140nm for 1300nm wavelengths.
   4. Output Stability +/- 0.40 dB from 0 to 50 degrees C
   5. Long Term output stability +/- 0.10dB at 25 degrees C Connector types to include: LC only.

D. Optical Power Meter – Single Mode
   1. Corning Cable Systems, Fluke or equal
   2. Minimum Performance - Single Mode Power Meter 1300nm and 1500nm +/- 20 nm wavelength laser light sources.
   3. Output Stability +/- 0.40 dB from 0 to 50 degrees C
   4. Long Term output stability +/- 0.10dB at 25 degrees C Measurement range shall be from 10 to -60 dBm
   5. Accuracy shall be +/- 5% at 0 to -50dBm and +/- 10% 10 to 0dBm and -50 to-60 dBm.
   6. Resolution shall be 0.1 dB
   7. Connector types shall include LC only.
   8. Optical Time Domain Reflectometer. (Fluke, JDSU or equal).

3.8 EXAMINATION & ACCEPTANCE

A. Testing Results Review and Verification by the Owner

1. Contractor shall submit (1) copy of software capable of viewing the electronic test result files.
2. Data found to be altered from the manufacturers recommended settings may result in retention by the Owner of a 3rd party test company to retest the installed cabling at the expense of the Contractor.
3. Events exceeding industry standards will cause the test result to be rejected. Direct review by
4. Owner IT will be required to allow for an exception of a test result.
5. Data found to be incomplete may result in retention by the Owner of a 3rd Party Test Company to retest the installed cabling at the expense of the Contractor.

3.9 FINAL REVIEW

1. Walk each route defined in preparation section and describe the diverse and redundant routes taken for each and all backbone cables.
2. Produce documentation and illustrate during walk thru the labeling completed.
3. Provide UL listings and display conformance to all Fire ratings and UL listings between all locations. Provide signed inspections reports depicting authority having jurisdiction approval of all work completed.

END OF SECTION

SECTION 271343

COMMUNICATIONS SERVICES CABLING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Outdoor (Outside Plant) Communications Cabling placed underground in existing communications ducts.
   1. High pair count copper cabling
   2. Fiber Optic Cabling
   3. Terminate fiber on patch panels as specified in Section 271119
   4. Terminate copper cabling on lightning protectors as specified in Section 270500

B. For all cabling
   1. Test cabling to demonstrate performance to specified standards or better using test equipment and methods as specified in Section 270500.
   2. Label cables, jacks, plates, and patch panels as specified in Section 270553.
   3. Document on Record Documents as described in Section 270500.

1.2 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

J. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

K. 271300 COMMUNICATIONS BACKBONE CABLING

L. 271500 COMMUNICATIONS HORIZONTAL CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

1.3 REFERENCES

A. In addition to the requirements of Section 270500 - Common Work Results for Communications, conform to the applicable portions of the following standards agencies:
   1. BICSI
   2. Customer Owned Outside Plant Design Manual, Latest Edition.
   3. Conform with the requirements of Section 270500 - Common Work Results for Communications

1.4 SUBMITTALS

A. All submittals shall be approved by IT Facilities.

1.5 SEQUENCING

A. Complete entrance facilities prior to need for communications to fire life safety.

B. Complete Section 271300 to facilitate need for communications to fire life safety.

PART 2 - PRODUCTS

2.1 FIBER OPTIC CABLING

A. As specified in Section 270050 – Common Work Results for Communications

B. Fiber Optic Cable, Outside Plant:
   1. AFL
   2. Corning
   3. Approved Equal

C. Drawing References:
   1. F-XXX Multimode, where XX indicates fiber count.
   2. F-XXX Single mode, where XX indicates fiber count.
   3. Contact Owner Representative for next sequenced designation number.
   4. Contact Owner Representative for underground plant MAP.

D. Refer additionally to Fiber Cable Construction, General, and elsewhere herein.
   1. Adhere to TIA-455 or TIA-568c.3 or applicable.

E. Suitable and approved for wet location/direct burial.

F. Loose Tube, Gel Filled Construction
   1. Armored/rodent resistant construction.
   2. Jacket:
      a. Polyethylene, polyurethane, or PVC.
   3. 0.040" minimum thickness.

G. Performance:
1. Maximum attenuation per EIA/TIA-455-61
2. Multimode
3. 850 nm: ≤ 3.5 dB/km
4. 1300 nm: ≤ 1.0 dB/km
5. Single mode
6. 1300 nm: ≤ 0.6 dB/km
7. 1550 nm: ≤ 0.5 dB/km

H. Maximum required bend radius:
1. At installation: 20x's diameter
2. Long term application: 10x's diameter
3. Zero water entry per FOTP-82, 24 hours immersion
4. Crush resistance: 600N/cm min per EIA-455-41
5. Impact Resistance: 25 impacts, per FOTP-25
6. Flex, Twist/Bend: 25 cycles, per FOTP-104 and FOTP-85

I. Loose Tube Manufacturer:
1. General Cable
2. AFL
3. Approved Equal

2.2 OPTICAL FIBER SPLICE CLOSURE

A. Functions/Features
1. Provide re-enterable underground or inside plant splice closure as shown on the Drawings.
2. Metal Stainless Steel or plastic construction – no corrodible materials.
3. Waterproof, suitable for direct burial.
4. Fusion splice protection chamber.
5. Grommet cable entrance and exits.

B. Manufacturers
1. Preformed Line Products Coyote Series.
2. AFL Apex.
3. Or approved equal.

C. Copper OSP Cabling

2.3 TELEPHONE, OUTSIDE PLANT, UNDERGROUND IN DUCTBANK

A. Drawing Reference: xx CU, with pair counts and Building Termination as indicated.

B. Features/Functions
1. Solid round copper wire individually bound per REA PE-39 color coded.
2. Meets RUS REA 1755.390.
3. Solid aluminum tape overall shield.
4. Gel filled.
5. Polyethylene Overall Jacket.
6. Suitable for direct burial.

7. 6 to 3000 Pair counts available.

C. Manufacturer
1. General Cable
2. Any meeting REA PE-39 for cable smaller than 400 pair.
3. Any meeting REA PE-39 or REA PE-89 for cable 400 pair or larger.
4. Or approved equal.

2.4 OUTSIDE PLANT HORIZONTAL CABLING
1. General Cable. GenSPEED 6 Category 6 Outside Plant Cable, Part No. 7136100.
2. Or approved equal.

2.5 SHIELD CONNECTORS

A. Shield connectors shall make a stable, low-impedance electrical connection between the shield of the communications cable and a conductor such as a strap, bar, or wire.

B. The connector shall be made of tin-plated tempered brass.

C. Shield bond connectors shall comply with REA PE-33.

2.6 GROUNDING BRAID

A. Grounding braid shall provide low electrical impedance connections for dependable shield bonding.

B. The braid shall be made from flat tin-plated copper.

2.7 OUTSIDE PLANT TELEPHONE CABLING CLOSURES

A. In Building Telephone Closure:

B. Drawing Reference: IBTC

C. Features and Functions:
1. Provides transition point from unlisted, gel-filled Outside Plant Cabling to Interior (CU) cabling.
2. Can house a straight, butt, and branch splice in a protective housing.
3. Not pressurized or encapsulated.
4. Fire-retardant Plastic construction, meeting PUB55006 for interior (in-building) installation.

D. End Caps
1. Multiple End caps shall be sized precisely to fit the diameter of the tip cables entering the closure.
2. Number of openings in the multiple end caps shall be determined by dividing the number pairs in the feed cable by 100 and doubling that number. (i.e., 1200 pair cable would have 24 openings for tip cables.
3. Collared Cap opening can be up to 6.35mm (1/4") larger than the feed cable diameter.

4. Actual end cap to be provided shall be based on the diameter of the feed cable to be spliced.

E. Plugs
1. Use tapered or collared plugs as required to fill extra opening in end caps.
2. Seal if inside diameter of hole is less than 6.35mm (.25").

F. Bushings
1. Use rubber or variable bushings as required to reduce standard opening in end caps to accommodate custom diameters.
2. Seal if inside diameter of hole is less than 6.35mm (.25").

G. Manufacturer
1. UraSeal 2000FR Type.
2. 3M K&B Series.
3. Tyco Electronics.
4. Or approved equal.

2.8 OUTSIDE PLANT TELEPHONE CLOSURE, VAULT

A. Drawing Reference: OTC, TOSC

B. Features/Functions
1. Stainless Steel outer jacket housing
2. Can house a straight, butt, and branch splice in a protective housing.
3. Rigid outer protective body
4. Suitable for periodic water immersion - air and watertight.
5. Renter able.
6. Gel Filled, Injected encapsulant using precision means.
7. Minimum inside diameter shall be 5" (127mm).
8. Minimum inside length shall be 26" (660mm).

C. Manufacturer
1. Preformed Line Products Armadillo Stainless.
2. UraSeal
3. 3M
4. Emerson Network Power
5. Or approved equal.

2.9 MULTIPAIR SPLICING CONNECTORS

A. Drawing Reference: None. Provide at all IBTC, TOSC, OTC and similar locations were shown on the plans or required in the field.

B. Function
1. Can provide gas tight terminate large pair counts of copper cabling to connectorized ends and reliable mate ends in compact area.
2. Industry standard termination means.
3. All modules shall have test entry ports on the front side of the module.
4. All straight splicing modules shall be tap modules.

C. Manufacturer
   1. 3M 710 (Industry standard item).
   2. Or approved equal as required to match the standard used at the facility.

2.10 MISCELLANEOUS UNDERGROUND PRODUCTS

A. Encapsulant
   1. Encapsulates shall be transparent.
   2. Splice case and Encapsulant must be re-enterable.
   3. Shall be compatible with the cable insulation.
   4. Shall not be corrosive to copper and must not support fungi or mold growth.

2.11 WATER IMPERMEABLE CONDUIT PLUGS
   1. Tyco RDSS Duct seal / E7512-160 / E7512-160.
   2. Jack moon compression plugs.
   3. Or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide safety barriers and flag persons for all open manholes and pull-boxes that are in areas accessible to the public.

B. Provide traffic control in accordance with the requirements of Campus policies and standards. Conform to OSHA guidelines when accessing manholes and handholes, inclusive of the requirement for air sampling. Provide continuous measurements. Provide the Owner's Representative with contractor-maintained logs of air samples taken at most two hours apart.

C. Provide sufficient personnel to permit one individual to always remain above the surface, in visual contact with persons in manholes and similar. Provide the observer with an appropriate means of obtaining assistance.

D. Provide ladders for access to manholes. Do not permit workers to use cables or splice cases as ladders.

E. Install a 3/8" nylon pull rope with all underground cables.

3.2 CABLE PULLING

A. Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables.

B. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

C. OSP Copper Cabling Special Procedures

1. Contractor shall provide notice 2 days in advance notice prior to pulling any cable greater than 400 pairs in size or when a winch is planned for use.
2. Owner's representative shall have the option to be present to observe all pulling activities of cable greater than 400 pair or when a winch is planned for use.
3. Contractor shall be responsible for verifying that ducts are ready for occupancy prior to cable placement.
4. Contractor shall assume responsibility for any difficulties or damage to the cable during placement.
5. Adhere to all manufacturers requirements regarding pulling tension allowable lubricants and bending radius.
6. All un-terminated cable pair ends must be cleared (not shorted or crossed) and binder tagged.
7. All open-ended cables must be watertight sealed using temporary end caps or encapsulation.

3.3 CABLES IN MANHOLES, PULL BOXES AND HANDHOLES

A. Support cable splices in underground structures by racks on each side of the splice.

B. 100 ft of slack shall be installed (in aggregate) at one or more maintenance vaults to accommodate possible service outage and cable repairs.

C. Wrap each vault when passing thru each Maintenance Hole.

D. Install cables at middle and bottom of cable racks, leaving top space opening or future cables, except as otherwise indicated for existing installations.

3.4 BUILDING ENTRANCE CONDUIT WATER BARRIER

A. Conduits entering a structure are to penetrate the last vault at the highest elevation possible to prevent water penetration.

B. All Conduits entering a structure are to be sealed and watertight from the last vault to the MPOE, TR or ER.

C. NO conduits shall be sealed (other than fire stopping materials required by the AHJ) inside the structure.

3.5 SERVICE LOOP AND TRANSITION SPLICE AT BUILDING ENTRY

A. For outside plant, flooded cables of 100 pair or greater entering a Building Distribution Facility or Entrance Facility, provide a transition in a splice case, Type IBTC, to non-flooded cable prior to termination on the protector blocks. Unless otherwise indicated on the plans, position the splice case high on the backboard, parallel to the floor at location suitable for service and where gel will not be drawn from the serving outside plant cabling into the IBTC.

B. At Telecommunications Rooms, at both ends of cables, provide at least 20 feet of cable in excess of that required to reach the protectors or terminal block by a dressed route. Form into a storage

loop, typically around the perimeter of the backboard and fix in place as directed by the Owner's Representative.

C. Bonding Harnesses shall be used to ground the shields of the spliced cables to the TGB or building service ground. Bonding harness shall be 14 AWG and sized according to closure.

D. Refer to Section 271300 – Communications Backbone Cabling for additional requirements for termination within Telecommunications Rooms.

END OF SECTION

SECTION 271500

COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Provisioning, installation, termination, and testing of twisted pair, horizontal cabling in modular furniture and hard wall workstations located throughout the project area. Work under this section will include:
   1. Wireless Access Point cabling
   2. Printer Stations
   3. IP Camera Cabling
   4. Monitor and CATV cabling
   5. IP Medical Equipment in Exam Rooms
   6. All workstation cabling as defined on the construction documents

1.2 TYPICAL WORK AREA OUTLETS

A. A typical work area outlet (per chair) or (Drop) shall consist of two (2) (Purple end to end) Category 6A Data cables, unless otherwise indicated.
   1. When re-cabling a building or office consideration shall be made to add Data Cables to support devices that will continue to be viable after a transition to a VoIP network such as fax machines, fire alarms, elevator phones, pay phones etc.

B. A typical work area outlet shall have a slack loop of 10 feet at the field end of the run.

1.3 OTHER OUTLET CONFIGURATIONS

A. Wireless Access Points
   1. A typical wireless access point (WAP) Outlet shall consist of two (2) (Purple end to end) Category 6A Data cables, unless otherwise indicated.

B. Timeclock Outlet
   1. A typical time cock outlet shall consist of one (1) (Purple end to end) Category 6A Data cable, unless otherwise indicated.

C. Other outlet configurations as defined by and coordinated with Owner IT.

D. All Outlet types listed above shall have a slack loop of 10 feet at the field end of the run.

1.4 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

J. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

K. 271300 COMMUNICATIONS BACKBONE CABLING

L. 271343 COMMUNICATIONS SERVICES CABLING

M. 275319 INTERNAL CELLULAR, PAGING, AND ANTENNA SYSTEMS

PART 2 - PRODUCTS

2.1 MODULAR JACK COMPONENTS, GENERAL

A. Modular Jacks rated Category 6A
   1. Panduit Mini-Com CJ6X88TGVL.
   2. Colored Icons as needed per UCDM service designation.
   3. Panduit PAN_CID(XX).

2.2 COPPER CABLING, CATEGORY 6A

A. High Speed, TIA category 6A Cabling, Plenum Rated
   1. General Cable GenSpeed 6A Part No.7141877 Purple
   2. General Cable GenSpeed 6A Part No. 7151855 Purple
      a. Use of the improved Genspeed cable is dependent on availability. Do not default to this cable if lead times are excessive.

2.3 TELECOMMUNICATIONS OUTLET COMPONENTS

A. Modular Furniture Surface Mount Box, Black
   1. Panduit CBXQxBL-A Where x = number of ports
   2. Modular Surface Mount Box Attachment System Mini-Com CBM-X
   3. Modular Surface Mount Box Blank Insert Panduit CMB(BL)

B. Faceplate

1. Panduit- Mini-Com Faceplates (CFP (2,4,6) SY I CFP (4,8,10) S-2GY
2. Coordinate finish with Architect prior to submittals

C. Faceplate Blank Insert
1. Panduit CMB(WH)

D. Stainless Wall Telephone Outlet
1. Leviton 40223-S (where specified)

E. One Hole Wall Plate
1. Leviton 84004-40 Stainless where requested.
2. Leviton 80720-W White where requested.
3. Coordinate finish with Architect prior to submittals.

F. Black Loom
1. Panduit loom CLT100F/CLT150F (choose size appropriate for cable installation quantity)
2. Thomas & Betts black liquid tight EFC150

G. Duplex In-Line Jack frame, one to four jacks (only where required, NOT standard installation)
1. Panduit Mini-Com 106 Duplex Module Frame

PART 3 - EXECUTION

3.1 CABLING RUN LENGTHS

A. Distance limitation of the in-wall cabling shall be thoroughly reviewed and calculated to be less than 275' when including the anticipated plug pack cabling length in the telecommunications room (TR).

B. Contractor to field verify the performance including cable length of the proposed installation in a mockup using the proposed cabling, jacks, raceway, and test equipment prior to proceeding.
1. Locate proposed cable pathway drawing for the upcoming cable run.
2. Contractor to install One (1) typical copper work area outlet complete with jacks at both ends.
3. Use the proposed pathway and cabling to the furthest location from the TR.
4. Install a cable simulating the cable length of the Plug Pack configuration.
5. The cabling contractor is to perform testing of these cables patched together to determine the true length of this mockup.
6. Test Results are to be inspected and reviewed by the University's Representative prior to proceeding with the rest of the installation.
7. Any deficiencies in the installation of the mockup are to be corrected by the Contractor and re-inspected by the University's Representative prior to proceeding with the rest of the installation.

3.2 MODULAR JACK COMPONENTS

A. Category 6A Data Jacks performance shall meet requirements as defined in TIA standards.

B. Follow manufacture's Installation procedures.

3.3 TELECOMMUNICATIONS OUTLET EXECUTION

A. Modular Furniture Surface Mount Box, One to Four Jacks
   1. Surface mount box magnetically attached to furniture.
   2. Removing knockouts in the base of the furniture shall be avoided.

B. Telecommunications Outlets. New, Copper Jacks, Wall Mount, Flush Mount Assembly.
   1. Complete outlet assembly, including but not limited to:
   2. Faceplate with manufacturer's standard jack openings
   3. Blank connector modules at faceplate openings not filled with connector modules.
   4. Features: Single gang with openings for the required number of cables. Provide flat stainless steel.
   5. Features: Double gang with openings for the required number of cables. Provide flat stainless steel.

C. Voice Telephone Station Plates and Jacks (special provision)
   1. Wall Mounted Analog Telephone
   2. Wall mounted IP Telephone Station
   3. Single outlet wall plate w8P8C data Jack

3.4 COPPER CABLING DATA VOICE/DISTRIBUTION

A. Maintain the following clearances from EMI sources (Per BICSI Standards)
   1. Power cable – 6 in.
   2. Fluorescent Lights - 12 in.
   3. Transformers- 48 in.

B. Monitor cable length limitations.
   1. All cable installations shall be continuous, unsliced runs
   2. All wiring above ceilings shall be installed in cable tray or cable hangers.
   3. Cable in accessible ceilings shall be supported 5' on center (min) attached to building structure.
   4. Cable shall have no physical defects such as cuts, tears, or bulges in the outer jacket.
   5. Cables jackets that are chaffed or burned exposing internal conductor insulation or have any bare copper ("shiners") shall be replaced.
   6. Limit cable bends to a minimum radius of 4 times cable diameter except where otherwise noted herein.
   7. Refrain from exceeding fill ratio on horizontal cabling installations
   8. Service loop at ALL TERMINATIONS
   9. Provide slack, which is to be no less than 2.5" and no greater than 5.0", in the station cable at the station outlet end. The Work Area Outlet shall provide enough slack to be serviceable without excess.
   10. Service loop at outlet locations: Provide a (10') Ten Foot Slack Loop for all horizontal cabling.
   11. All data and voice station cable shall be terminated at the individual receptacle modules in accordance with ANSI/TlA-568-C, assignment T568B.

3.5 TESTING

A. All system cabling and terminations shall be installed in accordance with manufacturer's instructions and as indicated on Contractor's submittal documentation, prior to final acceptance/approval by the University.

B. Installation shall be performed and accomplished in a professional manner, by qualified personnel.

3.6 PERFORMANCE STANDARDS

A. Horizontal (Station) category 6A Copper cabling - Permanent Link
   1. Testing shall commence while the University's equipment in the area of service is operational and creating worst case emissions associated with its operation while in good working order. Every effort shall be made to include worst case influence on the materials installed shall be taken.
   2. In accordance with the field test specifications defined in TIA-568-C.2 "Commercial Balanced Twisted-Pair Telecommunications Cabling and Components Standard", every horizontal station cabling link in the project shall be tested for:
      a. Wire Map Length Insertion Loss NEXT Loss
      b. PS NEXT Loss
      c. ACR-F Loss
      d. PS ACR-F Loss
      e. Return Loss
      f. Propagation Delay
      g. Delay Skew

B. Using the listed category 6A cable test set, test installed cabling using Permanent Link procedure and submit report demonstrating that the link meets the following:
   1. Each permanent link shall demonstrate a positive PSACR beyond 350 MHz to meet and exceed the bandwidth requirements of TIA-568-C.2 Category 6A standards.
   2. Each permanent link shall demonstrate 2 dB of cross talk headroom over TIA -568-C.2 Category 6A standard for NEXT, PSNEXT, ELFEXT and PSELFEXT bit error rate.
   3. Report whether tested link passes or fails.
   4. Note exceptions to required Category standards. Remedy and retest.
   5. Test and report on each intermediate cabling segment separately, including station cabling, horizontal distribution (each segment, if multiple) and telecommunications room wiring.
   6. Test each end-to-end cable link
   7. Submit machine-generated documentation and raw data of all test results on Contractor-provided, and University's Representative approved, forms; and in electronic format approved by the University's Representative.
   8. Test stations wire only after all pairs of station wire in a work area have been terminated at both ends, and no work of this Section or other Sections may cause physical disturbance to the wiring.
   9. Correct all transpositions found. Retest.
   10. If any conductor in a station wire tests either open or short, then the entire station wire is to be removed, replaced, and re-tested.
   11. The Contractor shall test all cables and submit all horizontal copper cable test result data in electronic format, with the resulting file formatted with one test result per 8.5"x 11"

page. Export or download the test results from the cable tester to a •.txt format or other accepted proprietary format for submission.

12. Data found to be altered from the manufacturers recommended settings may result in retention by the University of a 3rd Party Test Company to retest the installed cabling at the expense of the Contractor.
13. Events exceeding industry standards will cause the test result to be rejected. Direct review by UCD IT will be required to allow for an exception of a test result.
14. Data found to be incomplete may result in retention by the University of a 3rd Party Test Company to retest the installed cabling at the expense of the Contractor.
15. Contractor shall submit (1) copy of software capable of viewing the electronic test result files. Testing Results shall be reviewed and verified by the University before payments are remitted.

C. Test Equipment

1. Contractor shall provide all test equipment as required to perform the scope of work.
2. Test the communication systems cabling using at least one (1) each of the following test measurement devices or their functional equivalents:
    a. Level III field testers as defined in TIA-1152 - Fluke DSX-5000, or equal.
    b. The tester including the appropriate interface adapter must meet the specified accuracy requirements. The accuracy requirements for the permanent link test configuration (baseline accuracy plus adapter contribution) are specified in Table 4 of TIA-1152
    c. The RJ45 test plug shall fall within the values specified in TlA-568-C Annex C for NEXT, FEXT and Return Loss.
    d. The tester interface adapters must be of high quality and the cable shall not show any twisting or kinking resulting from coiling and storing of the tester interface adapters.
    e. To deliver optimum accuracy, permanent link interface adapter for the tester shall be used, which can be calibrated to extend the reference plane of the Return Loss measurement to the permanent link interface.
    f. The contractor shall provide proof that the interface has been calibrated within the period recommended by the vendor.
    g. To ensure that normal handling on the job does not cause measurable Return Loss change, the adapter cord cable shall not be of twisted-pair construction.
    h. Site portable communications systems (walkie-talkie, cell phone, or similar to aid in communications between test device locations)

END OF SECTION

SECTION 275319

INTERNAL CELLULAR AND ANTENNA SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This specification describes technical and performance criteria for deploying two separate Neutral-Host Distributed Antenna Systems (DAS) one capable of supporting Wireless Service Providers (WSP) and the other Public Safety Networks (PSN). The DAS components specified in this document include Donor Antennas, Coverage Antennas, Coax Cable, Coax Connectors, Splitters, Combiners, Couplers, Fiber-Optic Cable, Fiber-Optic Connectors, and Fiber-Optic Jumpers, Copper Cat6A Cable, Bi-Directional Amplifiers (BDA), Fiber-Optic Master Unit and Fiber-Optic Remote Units.

1.2 RELATED SECTIONS

A. 270500 COMMON WORK RESULTS FOR COMMUNICATIONS

B. 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

C. 270529 HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

D. 270533 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

E. 270536 CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

F. 270553 IDENTIFICATIONS FOR COMMUNICATIONS SYSTEMS

G. 271116 COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

H. 271119 COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

I. 271123 COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK

J. 271126 COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

K. 271300 COMMUNICATIONS BACKBONE CABLING

L. 271343 COMMUNICATIONS SERVICES CABLING

M. 271500 COMMUNICATIONS HORIZONTAL CABLING

N. 274133 MASTER ANTENNA TELEVISION SYSTEMS

O. 275116 PUBLIC ADDRESS SYSTEMS

P. 275213 PATIENT MONITORING AND TELEMETRY SYSTEMS

Q. 275223 NURSE CALL/CODE BLUE SYSTEMS

R. 275313 CLOCK SYSTEMS

1.3 SYSTEM DESCRIPTION

A. Design shall use iBwave (RF-Vu + RF-Propagation) software.

B. Services: Upon commissioning, the DAS systems shall provide coverage for the WSPs and PSNs listed below on all frequencies currently being used by the designated WSPs and PSN in the given market.
   1. NOTE: Consult with University IT representatives for opportunities to reduce scope
      a. AT&T
      b. T-Mobile
      c. Verizon
      d. 700 MHz Public Service
      e. 800 MHz Public Service 800 MHz UCDH & Sacramento County PSN coverage
      f. UC frequencies (806.0750/808.4875/851.0750/853.4875)
      g. 929.6125 Commercial Area Paging Systems

C. Expansion: Without replacing the Passive DAS Infrastructure, the DAS shall have expansion capabilities to support the following WSP and PSN frequencies deployed in a SISO antenna environment. Any additional Components required for system expansion shall comply with all specifications of this Section.

Service	Uplink	Downlink
Cellular	824 - 849	869 - 894
PCS	1850 - 1915	1930 - 1995
AWS	1710 - 1755	2110 - 2155
700 LTE	698 – 716, 777-787	728 - 757
700/800 Public Safety	793-805, 806-824	763-775, 851-869
SMR 800 (iDEN 800)	806 - 824	851 - 869
SMR 900 (iDEN 900)	896 - 902	929 - 941
BRS/EBS	2496 - 2690	
Commercial Paging		929.6125

D. 800 MHZ on Hospital Campus & vicinity P25 Frequencies required

SRRCS CHANNEL NUMBER	FREQUENCY	
1	853.8750	Control Channel
2	853.4500	Control Channel
3	853.1875	Control Channel
4	852.3500	Control Channel
5	852.0750	
6	851.6000	
7	853.9000	
8	853.6125	
9	853.1625	
10	852.5750	
11	851.8250	
12	851.6250	
13	853.7125	
14	852.7375	
15	852.4625	
16	852.3000	
17	851.7500	
18	851.3875	
19	853.8000	
20	852.6875	
21	851.8500	
22	851.6750	
23	851.3250	
24	851.0500	
25	853.2625	
26	852.2500	
27	851.8000	
28	851.6500	
29	851.4375	
30	851.2625	

E. The WSP DAS shall not use coaxial cable to distribute RF signals to the radiating points.

F. The WSP system architecture design shall be a CommScope ERA - DAS and consist of:

1. WIN – Wireless Intelligent Node
2. CAN – Central Access Node
3. TEN – Transport Extension Node
4. Access Points – UAP (Universal Access Points) indoors only & CAP-X (Carrier Access Point Low Power) outdoors only.

G. The proposed WSP DAS shall utilize structured cabling that complies with the following specifications.

1. ISO/IEC 11801 and EN 50173-1 Category 6A/ Class EA cabling specifications or ANSI/TIA-568-C cabling specifications for balanced cabling.

H. The WSP DAS shall self-detect its components and send alarm notifications when it detects network issues.

I. WSP Approval: The Contractor shall propose and deploy a DAS system capable of receiving WSP Approval for connection to the WSPs' macro networks.

J. PSN Approval: The Contractor shall propose and deploy a DAS system capable of receiving approval of the PSN Authority Having Jurisdiction (AHJ).

K. Broadband Active Distribution: Single-mode fiber-optic cable will be used for Active distribution. In-line amplifiers are not allowed.

L. Network Management:

1. NMS: The DAS shall have a Network Management System (NMS) capable of alarm, monitor, configuration, and control of all Active Components.
2. SNMP Integration: The DAS NMS shall be capable of integration with 3rd party SNMP based NMS products for alarm purposes and provide alarming information.

1.4 ALTERNATIVES

A. No alternative component(s) shall be accepted as equal to the components and manufacturers specified in this document unless the Contractor proves the alternative component(s) are of equal or superior specifications and quality, and that they have been used in similar projects of size and complexity for no less than 3 years. The following information shall be required for each alternative component with submittal of the bid response:

1. Passive Components:
   a. Product samples.
   b. Detailed product specifications.
   c. Independent test results verifying the product specifications.
   d. Written documentation from the manufacturer guaranteeing the alternative component(s) shall remain available for new purchase for a period of 7 years from the date of system acceptance.
2. Active Components:
   a. Hardware and software manuals
   b. Detailed product specifications
   c. Mean Time Between Failure (MTBF) data for each Active Component

d. Independent test results verifying the product specifications.
e. Written documentation from the manufacturer guaranteeing the alternative component(s) shall be supported for a period of 7 years from the date of system acceptance.
f. For Active Components serving the WSP's, written documentation from the WSPs that the alternative component(s) are approved for use within the WSP's network and that connection of the DAS to the WSP's network will not be withheld due to the alternative component being used in the DAS.
g. For Active Components serving the PSN, written documentation from the AHJ that the alternative component(s) are approved for use within the PSN and that system acceptance of the DAS to the PSN will not be withheld due to the alternative component being used in the DAS.

1.5 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance, and testing shall comply with the latest editions of the National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

B. Requirements set forth by first-responder code, ordinance, or the PSN AHJ shall supersede the requirements described herein and shall be met in their entirety. It is the Contractor's responsibility to ensure that the DAS complies with local code, ordinances or requirements established by the PSN AHJ.

C. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid. Consider such codes or standards a part of this Specification as though fully repeated herein.

D. Codes: Perform Work executed under this Section in accordance with applicable requirements of the latest edition of governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:

E. United States Department of Labor (DOL) Regulations (Standards - 29 CFR)
1. Part 1910, "Occupational Safety and Health Standards"
2. California Code of Regulations (CCR) Title 24, California Building Standards Code Part 2, Basic Building Regulations and Part 3, California Electrical Code (CEC).
3. 2016 California Building Code (CBC).
4. 2016 California Fire Code (CFC).
5. 2016 California Mechanical Code (CMC).
6. National, State, and any other binding building and fire codes.
7. FCC Regulations:
   a. Part 15 – Radio Frequency Devices & Radiation Limits
   b. Part 68 – Connection of Terminal Equipment to the Telephone Network
8. Standards: Equipment and materials furnished under this Section shall conform to the following standards where applicable:

9. Underwriter's Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
   a. UL 444: Communications Cables
   b. UL 497: Protectors for Paired-Conductor Communication Circuits.
   c. UL 1651: Optical Fiber Cable
   d. UL 1690: Data-Processing Cable
   e. UL 1963: Communications-Circuit Accessories
   f. UL 2024A: Optical Fiber Cable Routing Assemblies.
10. ANSI/TIA/EIA-568-D Commercial Building Telecommunications Cabling Standard.
   a. Part 1: General Requirements
   b. Part 2: Balanced Twisted-Pair Cabling Components
   c. Part 2, Addendum 1: Transmission Performance Specifications For 4-Pair 100 Ohm Category 6 Cabling
   d. Part 3: Optical Fiber Cabling Components Standard
11. ANSI/TIA/EIA-569-E Commercial Building Standard for Telecommunications Pathways and Spaces, including all addenda.
12. ANSI/TIA/EIA-598-D Optical Fiber Cable Color Coding.
13. ANSI/TIA/EIA-606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
14. ANSI/J-STD-607-D Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
15. ANSI/TIA/EIA-758 Customer-Owner Outside Plant Telecommunications Cabling Standard.
16. TIA/EIA-758-1 Addendum No. 1
17. EIA testing standards.
18. Insulated Cable Engineers Association (ICEA):
   a. ANSI/ICEA S-80-576 Category 1 & 2 Individually Unshielded Twisted Pair Indoor Cables for Use in Communications Wiring Systems
   b. ANSI/ICEA S-83-596 Fiber Optic Premises Distribution Cable
   c. ANSI/ICEA S-87-640 Fiber Optic Outside Plant Communications Cable
   d. ANSI/ICEA S-90-661 Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cable for Use in General Purpose and LAN Communication Wiring Systems
   e. ICEA S-104-696 Standard for Indoor-Outdoor Optical Cable
19. Building Industry Consulting Services International (BICSI):
20. Telecommunications Distribution Methods Manual (TDMM)
21. Customer-Owner Outside Plant Design Manual
22. Wireless Design Reference Manual (WDRM)
23. Network Design Reference Manual (NDRM)

F. Make a copy of each document readily available during the course of construction for reference by field personnel.

1.6 ABBREVIATIONS AND ACRONYMS

A. AHJ: Authority Having Jurisdiction

B. ATP: Acceptance Test Plan

C. AWS: Advanced Wireless Service

D. BDA: Bi-Direction Amplifier

E. BOM: Bill-of-Material

F. DAS: Distributed Antenna System

G. DAQ: Digital Audio Quality

H. ESMR: Enhanced Specialized Mobile Radio

I. ERRCS: Emergency Responder Radio Coverage System (also see PSN)

J. FCC: Federal Communications Commission

K. iDEN: Integrated Enhanced Digital Network

L. LMR: Land Mobile Radio

M. LTE: Long Term Evolution

N. MTBF: Mean Time Between Failure

O. NMS: Network Management System

P. PCS: Personal Communications System

Q. PSN: Public Safety Network

R. RoF: Radio-over-Fiber

S. RoHS: Restriction of Hazardous Substances

T. RSL: Received Signal Level

U. SISO: Single-Input, Single-Output

V. SMR: Specialized Mobile Radio

W. SMS: Short Message Service

X. SNMP: Simple Network Management Protocol

Y. SOW: Statement of Work

Z. VSWR: Voltage Standing Wave Ratio

AA. WSP: Wireless Service Provider

1.7 DEFINITIONS

A. Acceptance: Expressed approval by the customer

B. Active: DAS components that require AC/DC power for operation

C. Cellular Access Unit: The Active device that allows the mobile devices to connect to the DAS network.

D. Channel: A path for an RF transmission between two points

E. Component: A main system element of the DAS

F. Contractor: The prime contractor bidding the project

G. Delivered Audio Quality (DAQ): A measure of audio quality over a transmission medium used to quantify the quality of audio heard over a radio system. DAQ levels are defined by the following scale:
1. DAQ 1: Unusable. Speech present but not understandable.
2. DAQ 2: Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.
3. DAQ 3: Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
4. DAQ 3.4: Speech understandable without repetition. Some noise or distortion present.
5. DAQ 4: Speech easily understandable. Little noise or distortion.
6. DAQ 5: Perfect. No distortion or noise discernible.

H. DAS Sub-contractor: A qualified and experienced DAS integrator performing the DAS deployment for the Contractor.

I. Head-End Equipment: The equipment that accepts the RF Source, and then typically attenuates, combines, filters, and converts the various RF Source signals before transmitting the RF signals to the Remote Units.

J. Passive: DAS components that do not require AC/DC power for operation

K. Remote Unit: The equipment that receives the RF signals from the Head-End Equipment, and then typically filters, converts, and often amplifies the RF signal before transmitting it to the coverage antenna or Cellular Access Unit.

1.8 PERFORMANCE REQUIREMENTS

A. Optical Fiber Infrastructure:
1. General: Optical fiber cabling shall be tested and certified after installation as described in Specification 27 13 00.

B. WSP DAS:
1. On a per channel basis, the downlink RSL for each frequency band shall meet or exceed the criteria in Table 1.

2. NOTE: Below table should be modified with project specific requirements especially in challenging RF environments. Below values apply to low noise and low congestion areas.
3. Table 1. System Parameters

Parameters	Unit	700 LTE	Cellular, PCS, AWS, Commer-cial 800/900 MHz	Public Safety 700, 800 MHz
Minimum down-links receive signal level (RSL)	dBm	-75	-85	-95

4. Ultimately it is the Contractor's responsibility to confirm that all design requirements for each WSP are met with their proposed solution. For example, in certain markets the WSP has a specific requirement for RSSI of -65 dBm at the windows.
5. Contractor shall state the assumed channel loading and frequency bands for the proposed WSP in-building coverage. Prior to installation, contractors shall confirm the channel loading and frequency use in the serving area and shall guarantee coverage for these channels per the criteria in Table 1.
6. The DAS shall deliver coverage per the criteria in Table 1 throughout 95% of the building. The coverage areas shall include the stairwells, elevators, basement, and garage.
7. The contractor shall explain the method used to avoid downlink and uplink interference.

C. PSN DAS:
1. Contractors shall state the assumed channel count for the PSN Frequency Bands identified above in Section 1.3. with submittal of bid response. Prior to installation, contractors shall confirm the channel count and frequencies with the AHJ and shall guarantee coverage for these channels per the criteria stated above.
2. The DAS shall be capable of upgrade, without additional hardware or software, to allow for changes to system frequencies within the deployed frequency band to maintain radio system coverage as originally designed.
3. The DAS shall deliver coverage per the criteria in Table 1 throughout 95% of the building. The coverage areas shall include the stairwells, elevators, basement, and garage.
4. The contractor shall explain the method used to avoid downlink and uplink interference.

1.9 ADDITIONAL REQUIREMENTS

A. WSP Approval: The Contractor shall be responsible for providing the WSP with information each WSP requires to approve connection of the DAS to the WSP's macro network.

B. PSN Approval: When approval of the DAS deployment is required by code or ordinance, the Contractor shall be responsible for facilitating the AHJ approval(s) per the requirements of the code or ordinance.

1.10 SUBMITTALS

A. Submittal Requirements with Bid Response:
1. Product Data: Submit manufacturer datasheets for the following components:
   a. Donor and Coverage Antennas or Access Points
   b. Coaxial Cable and Connectors (if used)

c. Splitters, Combiners and Couplers (if used)
d. Bi-Directional Amplifiers (BDA) (if used)
e. All active components included in the DAS

2. Shop Drawings: Submit the following items:
   a. RF link budget
   b. Overlay of system Components on floor plans
   c. Drawings for Donor Antenna and grounding
   d. Bill-of-Material (BOM)
3. Statement of Work (SOW): Submit sample SOW
4. Acceptance Test Plan (ATP): Submit sample ATP
5. Recommended Spares
6. Warranty Documents:
   a. Submit for all manufactured Components specified in this Section.
   b. Submit Contractor's System Warranty.
   c. Submit Manufacturer's Extended Warranty.

B. Submittal Requirements Prior to Start of Construction
1. Final RF link budget
2. Overlay of system Components on floor plans
3. Drawings for Donor Antenna and grounding (if used)
4. RF propagation modeling
5. Bill-of-Material (BOM)
6. Maintenance Service Contract
7. Statement of Work (SOW): The contractor shall submit a SOW that has been accepted by the customer or customer's designated representative.
8. Acceptance Test Plan (ATP): The contractor shall submit an ATP that has been accepted by the customer or customer's designated representative.

C. Submittal Requirements at Close Out
1. Drawings: Submit as-built drawings indicating:
   a. Donor antenna, grounding, and lighting protection details (if used)
   b. Cable routing, splitters, couplers, and coverage antenna locations
   c. Active component locations, layout, and configuration
2. Test Reports
   a. WSP DAS: Submit accepted ATP reports confirming the requirements of Section 1.8 have been met.
   b. PSN: Submit Accepted ATP reports confirming the requirements of Section 1.8 have been met.
3. Field Reports: Submit sweep-testing results for all cable runs.
4. Field Reports: Submit OTDR and End-to-End Power Measurement test results for all fiber runs.
5. Operation and Maintenance Data: Submit hardware and software manuals for all Active Components.
6. Warranty Documents:
   a. Submit for all manufactured components specified in this Section.
   b. Submit Contractor's System Warranty.
   c. Submit Manufacturer's Extended Warranty

1.11 QUALITY ASSURANCE

A. Qualifications and Requirements
   1. Contractor or DAS Sub-contractor shall have a minimum of 4-years full-time experience executing DAS work of similar scope and complexity.
   2. Contractor or DAS Sub-contractor shall have deployed a minimum of 10 DAS systems.
   3. Contractor or DAS Sub-contractor shall have the ability to remotely monitor DAS systems.
   4. Contractor or DAS Sub-contractor Project Managers must be PMI Certified.
   5. Contractor or DAS Sub-contractor shall provide an onsite construction foreman to oversee the installation.
   6. Contractor or DAS Sub-contractor shall provide a project manager to oversee the DAS deployment.

B. Certifications
   1. The manufacturer(s) of the DAS active components shall maintain a formal authorized and certified value-added reseller program, which consists of routine quality audits of the participating value-added resellers. The list of authorized value-added resellers shall be published, and the Contractor or DAS Sub-contractor shall be listed in the Manufacturer's publication of value-added resellers.
   2. Contractor or DAS Sub-contractor(s) shall provide manufacturer certification that their personnel have been trained on the passive and active components being installed.
   3. Contractor or DAS Sub-contractor shall be an authorized and certified value-added reseller for the proposed DAS manufacturer of passive and active DAS components.

1.12 WARRANTY

A. Manufacturer Warranty:
   1. Splitters, Couplers and Coverage Antennas: 5-year limited warranty from date of system acceptance.
   2. Coaxial Cable and Connectors: 10-year limited warranty from date of system acceptance.
   3. Fiber-Optic Cable: 25-year limited warranty from date of system acceptance.
   4. Active Components: The earliest of 1-year limited warranty from date of system installation or 15 months from date of shipment.

B. Contractor Warranty: Contractor shall warrant the system performance as specified in Section 1.8 for 1-year.

1.13 MAINTENANCE

A. The Contractor shall provide an optional annual maintenance service contract to include:
   1. Service Provider Coordination.
   2. Equipment Warranty Management.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Specified Manufacturers for PSN 50 Ohm passive DAS components: RFS, Andrew, Trilogy

B. Specified Manufacturers for PSN BDA Active components: JMA Compatible

C. Specified Manufacturers for WSP DAS Active components: Commscope

D. Specified Manufacturers for Optical fiber components: AFL

E. Acceptable Manufacturers: As permitted in Section 1.4

2.2 PRODUCTS

A. Cellular frequencies on or near the UC Davis Hospital Campus products used shall be Commscope product line or fully compatible.

B. Public safety 800MHZ, 900MHZ (those not in the cellular bands) shall be compatible with a JMA product line backbone distribution.

C. Off Campus Cellular, those not within ½ mile and directly linked with fiber infrastructure from the main hospital shall be WilsonPro for medium sized (25,000 sq ft per amp) building and CommScope for large multistory building redistribution systems.

2.3 COMPONENTS

A. Omni-Directional Coverage: Omni-Directional Coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna. (If UHF services are required as specified in Section 1.3, the specifications for the Omni-Directional Coverage antenna shall be Cel-Fi A11-V43-121 or functional equivalent.)

1. Electrical Band 1:
   a. Frequency Band: 698 –5900 MHz
   b. VSWR: ≤2.0:1
   c. Gain: 2 – 5.5 dBi
   d. Maximum input power:
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 80° nominal
   h. Return Loss: 10.9 dB
2. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: Thru-hole ceiling mount
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: KSR195, plenum rated
3. Environmental:

a. Application: Indoor
b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
c. Relative Humidity: Up to 100%

4. Regulatory Compliance/Certifications: RoHS 2002/95/EC

B. Directional Coverage Antennas: Directional coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna. (If UHF services are required as specified in Section 1.3, the specifications for the Omni-Directional Coverage antenna shall be Cel-Fi A52-V32-101 or functional equivalent.)

1. Electrical Band 1:
   a. Frequency Band: 698 –960 MHz
   b. VSWR: ≤ 1.8:1
   c. Gain: ≥ 6.5dBi @ 698 –960 MHz
   d. Maximum input power: 50W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 110° nominal
   g. Polarization: Vertical
   h. Return Loss: ≤ 10.9 dB
2. Electrical Band 2:
   a. Frequency Band: 1710 – 2700 MHz
   b. VSWR: ≤ 1.5:1
   c. Gain: ≥ 9dBi @ 1710 – 2700 MHz
   d. Maximum input power: 50W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 90° nominal
   g. Return Loss: ≤ 13.9 dB
3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: 4-hole wall mounting plate
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: RG58, plenum rated
4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%
5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

C. Air Dielectric, Plenum Rated Cable:

1. Material Characteristics:
   a. Jacket: Halogenated, Fire-Retardant
   b. Outer Conductor Material: Corrugated Aluminum or Corrugated Copper
   c. Inner Conductor Material: Copper-Clad Aluminum Wire
2. Electrical Characteristics:
   a. Impedance: 50 ± 2.0 Ω
   b. Frequency Band: 1 - 8800 MHz
   c. Peak Power Rating: ≥ 40.0 kW

3. Mechanical Characteristics:
   a. Diameter Over Jacket: ≤ .627 in
   b. Minimum Bending Radius: ≤ 5 in
   c. One Time Minimum Bending Radius: ≤ 3 in
4. Attenuation Characteristics:

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.848
450	≤ 1.53
800	≤ 2.105
2000	≤ 3.564

   a. Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)
5. Approved Manufacturer: Trilogy AP012J50 or equivalent, in accordance with Section 1.4.

D. Foam Dielectric Cable:
1. Material Characteristics:
   a. Jacket: Non-halogenated, Fire-Retardant Ployolefin
   b. Outer Conductor Material: Corrugated Copper
   c. Inner Conductor Material: Copper-Clad Aluminum Wire or Copper Tube
2. Electrical Characteristics:
   a. Impedance: 50 ± 1.0 Ω
   b. Frequency Band: 1/2" Nominal: 1 - 8800 MHz, 7/8" Nominal: 1 - 5000 MHz
   c. Peak Power Rating: ≥ 40.0 kW
3. Mechanical Characteristics:
   a. Diameter Over Jacket: 1/2" Nominal: ≤ .630 in, 7/8" Nominal: ≤ 1.1 in
   b. Minimum Bending Radius: 1/2" Nominal: ≤ 5 in, 7/8" Nominal: ≤ 10 in
   c. One Time Minimum Bending Radius: 1/2" Nominal: ≤ 2 in, 7/8" Nominal: ≤ 5 in
4. Attenuation Characteristics: 1/2" Nominal

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.815
450	≤ 1.447
800	≤ 1.968
2000	≤ 3.251

   a. Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)
5. Attenuation Characteristics: 7/8" Nominal:

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.417
450	≤ .744
800	≤ 1.014
2000	≤ 1.683

   a. Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

E. Splitters, Combiners, Couplers, and Coax Jumpers:
1. Approved Manufacturer: Comba, Micro Lab or equivalent, in accordance with Section 1.4.

F. BDA: When the WSP approves a BDA as the RF source, the BDA shall use digital filtering to mitigate interference and accommodate multiple services for PSNs and WSPs.
1. Characteristics

a. Operating Temperature Range: -33 °C to +50 °C
b. Filtering: Digital for Public Safety Bands
c. Separate Control: Each RF amplifier shall be capable of adjusting and controlling power levels for each WSP when multiple WSPs share a single amplifier.
d. FCC Part 90.219 Type Classification: Class A narrowband for LMR/SMR/ESMR frequency bands
e. Alarming: Shall support both SNMP and SMS using wireless modem

2. Compliance:
   a. FCC: Shall be FCC type certified.
3. Approved Manufacturers: Comba and JMA Compatible or equivalent, in accordance with Section 1.4.

G. RF over Twisted Pair System: When installation requirements dictate an RF over Twisted Pair DAS, the RF over Twisted Pair System shall convert radio over coax to Radio-Over-Cat6A for distribution to remote active access points. The system shall be capable of coexisting with existing Ethernet traffic on the same Cat 6A or better cable. The system must be approved by a minimum of one WLAN network vendor for use with their WLAN architecture.

H. Fiber-Optic Cable and Connectors:

1. General Specifications:
   a. Cables shall be twelve-fiber or greater, designed for point-to-point applications as well as mid-span access, and shall provide a high-level of protection for optical fiber installed in interior building environments.
   b. All cables shall be home run from each remote location to each Fiber Master rack without passing through any intermediate cross-connects. Intermediate splice/aggregation points are allowed.
   c. All cables shall be terminated with LC type connectors.
2. Single Mode Fiber General
   a. All fibers in the cable must be usable and meet required specifications.
   b. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
   c. Each optical fiber shall consist of a Germania-doped silica core surrounded by a concentric glass cladding.
   d. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m2).
   e. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
   f. The attenuation specification shall be a maximum value for each cabled fiber at 23±5 ºC on the original shipping reel.
3. Single-Mode (Dispersion Un-shifted)
   a. The single-mode fiber utilized in the optical fiber cable shall meet ITU G.652 (Tables A, B, C & D), IEC Specification 60793-2-50 Type B1.3, TIA/EIA 492-CAAB and Telcordia Generic Requirements GR-20-CORE.
4. Single-Mode (Dispersion Un-shifted) Bend Improved Loss Optical Fiber
   a. The single-mode fiber utilized in the optical fiber cable shall meet ITU G.652 (Table D), ITU G.657 (Table A1), IEC Specification 60793-2-50 Type B1.3 and Telcordia Generic Requirements GR-20-CORE.

5. Single-Mode (Dispersion Un-shifted) Bend-Tolerant Optical Fiber
   a. The single-mode bend-improved optical fiber utilized in the optical fiber cable shall meet ITU-T G.652, Table D, ITU-T G.657, Table A2 and B2, IEC Specification 60793-2-50 Type B1.3 and B6_b, and Telcordia Generic Requirements GR-20-CORE.
6. Single-Mode (Dispersion Un-shifted) Bend Insensitive Optical Fiber
   a. The single-mode bend insensitive fiber utilized in the optical fiber cable shall meet ITU G.652 (Table D) and ITU G.657 (Table B3).

I. Fiber-Optic Apparatus:
   1. General specifications:
      a. Panel shelves and wall mount housing shall be used for combination of splicing pigtails, direct connectorization, or PnP cabling. Shelf shall be designed for use as termination shelf only (direct connector termination) or as splice and termination shelf.
      b. Building cabling shall not terminate directly to equipment and patch panels shall be installed at both the head end and remote locations. Panels shall be sized to match fiber count of cable being installed as well as allow for future expansion.
      c. Solution shall be able to handle the internal termination of Composite copper DC power and optical fiber cable without the use of 3rd party components. Head end components shall be capable of inclusion of power limiting components that meet NEC requirements.
         1) Approved Manufacturer: AFL

J. Fiber-Optic Patch cords:
   1. General Specifications:
      a. To maintain channel integrity, optical fiber patch cords and pigtails shall be fabricated to meet the performance parameters corresponding to the optical fiber cable approved product type specified below. Patch cord and pigtail plug connectors shall be equipped with boots and shall have same colors as related optical fiber backbone cables, unless specified or indicated otherwise. Optical fiber patch cords shall be available with the following options as specified or indicated:
         1) Termination types: SC-APC, LC-APC for PSN DAS, LC-UPC for WSP DAS.
         2) Connector/cable configuration: Simplex for PSN DAS, Duplex for WSP DAS
         3) Fire ratings: Riser, plenum and/or LSZH
         4) Patch cord outside diameters: 2.0, 2.9 or 3.0 millimeters
         5) Lengths: As specified or indicated
         6) Approved Manufacturer: AFL or equivalent, in accordance with Section 1.4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Conditions: Verify conditions, provided under other sections, are acceptable for product installation in accordance with manufacturer's instructions.

B. Pathways: Verify that pathways and supporting devices, provided under other sections, are properly and permanently installed, and that temporary supports, devices, etc., have been removed.

C. Field Measurements: Verify dimensions of pathways, including length of pathways. For example, “true tape” the conduits to verify cabling distances.

3.2 FIELD QUALITY CONTROL

A. Staffing: Provide a qualified foreman who is in charge of the Work and who is present at the job site at times Work is being performed. Supervise the work force executing the Work. Perform the installation within the restraints of the construction schedule.

B. Project Management: Coordinate and attend weekly status meetings to review the overall progress and issues to be resolved throughout the course of construction. Prepare and distribute meeting agenda prior to and meeting notes after meetings in a format acceptable to the General Contractor.

C. Scheduling: Prepare an overall construction schedule based on the results of the planning meetings with the General Contractor. Issue schedule to General Contractor for approval. Prepare and issue updated schedules whenever there are modifications.

D. Inspection: Perform inspection after installation. Keep areas of work accessible and notify code authorities, or designated inspectors, of work completion released for inspection. Document completion, and inspection as required.

3.3 INSTALLATION

A. The contractor and/or DAS Sub-contractor shall design, install, commission, and test the DAS in accordance with the manufacturer’s instructions and recommendations.

B. The contractor and/or DAS Sub-contractor shall install the DAS in accordance with the accepted SOW.

C. The contractor and/or DAS Sub-contractor shall adhere to all work and safety requirements while working at the job site.

D. The contractor and/or DAS Sub-contractor shall have DAS project foreman on site overseeing the installation.

E. The contractor and/or DAS Sub-contractor shall have at a minimum one PMP certified Project Manager on staff overseeing the project. The Project Manager will be responsible for the following:
1. Developing and maintaining a project plan consistent with the overall milestones of the project.
2. Overseeing and coordinating the activities of the DAS project, including initiating, and holding weekly project conference calls, as well as maintaining and distributing meeting minutes.
3. Act as the point-of-contact interface for all DAS project activities.

4. Provide weekly status updates regarding work performed, worked scheduled, open items, problems/issues, and resolutions.

F. The contractor and DAS Sub-contractor shall be prepared to deploy the DAS in a phased approached as dictated by the building construction and/or work of other trades.

G. The contractor and DAS Sub-contractor shall facilitate PSN and WSP Approval and connection to their respective macro networks.

H. The contractor and DAS Sub-contractor shall be prepared to connect to the PSN and WSP's network(s) in a phased approached as dictated by the PSN and WSP's schedules.

3.4 ACCEPTANCE TESTING

A. Acceptance testing will be performed confirming the requirements of Section 1.8 have been met.

B. The contractor shall complete the WSP acceptance testing per the WSP's requirements and as prescribed in the approved WSP Acceptance Test Plan (ATP) submittal.
1. Must comply with FCC OET65C.

C. PSN Acceptance Testing
1. PSN Acceptance Testing shall comply with the following:
   a. The Acceptance Test shall ensure that two-way coverage on each floor of the building meets the minimum coverage requirements detailed in Section 1.8.
   b. Tests shall be made using the frequencies listed in Section 1.3.
   c. Testing shall be coordinated with the Customer and AHJ to ensure no undue interference to any public safety operations.
   d. All testing shall be done on frequencies authorized by the FCC.
2. Test Procedures
   a. The test plan shall ensure testing throughout the building. Testing shall be performed on a grid system. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. A grid is overlaid onto a floor area to provide 20 grid cells. Grid cells are provided with definite minimum and maximum dimensions. For most buildings, using a minimum grid dimension of 20 ft and a maximum grid dimension of 80 ft will suffice to encompass the entire floor area. A maximum of one area will be allowed to fail the test (95% coverage). Where a floor exceeds 128,000 sq ft, which is the floor area that can be covered by the maximum grid dimension of 80 ft, the floor be subdivided into 40 equal sectors, with each sector being tested individually. A maximum of two non-adjacent areas will be allowed to fail the test (95% coverage). In addition to the above requirement, all critical areas, which include the emergency command center(s), the fire pump room(s), exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by the AHJ, shall be provided with 99 percent floor area radio coverage. Signal strength measurements shall be performed using standardized parameters as specified below.
3. Measurement Parameters

a. Signal levels shall be measured to ensure the system meets the criteria specified in the Technical Proposal. Downlink measurements shall be made with the following standardized parameters:
b. Measurements shall be recorded using a calibrated spectrum analyzer or a calibrated automatic signal-level measurement recording system measuring RSSI in each band with a dipole antenna positioned approximately 4' above the surface.
c. If P25 Phase II TDMA signals are being measured, the system BER will be measured on a known P25 Phase II TDMA signal. The signal source for measuring the system BER will be provided by the AHJ. The downlink signal level will be measured and the BER will be determined. The DAS coverage will be considered acceptable if the measured BER is five percent (5%) or less.
d. In addition, the AHJ may conduct portable radio test to show true system performance for P25 Phase I and Phase II TDMA and FDMA services being used on the DAS. These tests shall be conducted using the DAQ scale. A successful test shall include any score measuring DAQ 3.4 or greater.
e. Measurements will be recorded for the test pattern as described above.
f. The System uplink noise floor will be measured by connecting a spectrum analyzer to the uplink output of the donor BDA to verify that it agrees with levels predicted by the design link budgets detailed in the Contractor's TF link budget submittals.
g. System acceptance is achieved when 95% of the averaged data points meet or exceed the requirements specified here and in Section 1.8.

3.5 DEMONSTRATION

A. On completion of the acceptance test, schedule a time convenient with the Owner or Owner's Representative for instruction in the configuration, operation, and maintenance of the system.

B. Provide 4 hours, minimum, of onsite orientation and training by a factory-trained representative. Document dates and times of training and submit a "sign in" sheet for individuals trained, as part of the close out documentation.

3.6 CERTIFICATION

A. Provide to Owner or Owner's Representative a written form of acceptance for signature. Corrections must be completed before Owner or Owner's Representative and Engineer will give acceptance.

END OF SECTION