



VOLUME 2 OF 2

ONEIDA COUNTY DEPARTMENT OF AVIATION

CONTRACT DOCUMENTS
FOR THE CONSTRUCTION OF

**RE-BID BUILDING # 504 AIR TRAFFIC
CONTROL TOWER RENOVATION
PROJECT**

**GRIFFISS INTERNATIONAL AIRPORT
ONEIDA COUNTY
ROME, NEW YORK**

FAA AIP PROJECT NO. 3-36-0119-064-2024 (D)

FAA AIP PROJECT NO. 3-36-0119-____-2025 (C)

NYS DOT PROJECT NO. 2905.55 (D)

NYS DOT PROJECT NO. 2905.____ (C)

ONEIDA COUNTY GENERAL CONTRACT No. H25-132-GC-02

ONEIDA COUNTY MECHANICAL CONTRACT No. H25-132-MC-02

ONEIDA COUNTY ELECTRICAL CONTRACT No. H25-132-EC-02

BID REFERENCE # 2333



OWNER:

ONEIDA COUNTY

GRIFFISS INTERNATIONAL AIRPORT

660 HANGAR ROAD, SUITE 223

ROME, NY 13441

(315) 736-4171

ENGINEER:

C&S ENGINEERS, INC.

499 COL. EILEEN COLLINS BOULEVARD

SYRACUSE, NEW YORK 13212

(315) 455-2000

BID DOCUMENTS

MARCH 28, 2025



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Michael W. LaMontagne RA, AIA

NO ALTERATION PERMITTED HEREIN EXCEPT AS PROVIDED UNDER SECTION 7209
SUBDIVISION 2 OF THE NEW YORK STATE EDUCATION LAW.

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Patching mortar.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete work, including, but not limited to, the following:
 - a. Verify concrete-maintenance specialist's personnel, equipment, and facilities needed to make progress and avoid delays.
 - b. Concrete restoration specialist.
 - c. Materials, material application, sequencing, tolerances, and required clearances.
 - d. Shoring and bracing.
 - e. Quality-control program.
 - f. Coordination with building occupants.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include construction details, material descriptions, chemical composition, physical properties, test data, and mixing, preparation, project application types consisting of horizontal, vertical or overhead locations and application instructions.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For concrete-maintenance specialist and manufacturers.
- B. Material Certificates: For each type of portland cement and aggregate supplied for mixing or adding to products at Project site.
- C. Product Test Reports: For each cementitious patching mortar, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Field quality-control reports.
- E. Quality-Control Program: Submit before work begins.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's written instructions for minimum and maximum temperature requirements and other conditions for storage.
- B. Store cementitious materials off the ground, under cover, and in a dry location.
- C. Store aggregates covered and in a dry location; maintain grading and other required characteristics and prevent contamination.

1.6 FIELD CONDITIONS

- A. Cold-Weather Requirements for Cementitious Materials:
 - 1. Do not apply unless concrete surface and air temperatures are above 40 deg F (5 deg C) and will remain so for at least 48 hours after completion of Work.
 - 2. Comply with the following procedures:
 - a. When air temperature is below 40 deg F (5 deg C), heat patching-material ingredients and existing concrete to produce temperatures between 40 and 90 deg F (5 and 32 deg C).
 - b. When mean daily air temperature is between 25 and 40 deg F (minus 4 and plus 5 deg C), cover completed Work with weather-resistant insulating blankets for 48 hours after repair or provide enclosure and heat to maintain temperatures above 32 deg F (0 deg C) within the enclosure for 48 hours after repair.
 - c. When mean daily air temperature is below 25 deg F (minus 4 deg C), provide enclosure and heat to maintain temperatures above 32 deg F (0 deg C) within the enclosure for 48 hours after repair.
- B. Hot-Weather Requirements for Cementitious Materials: Protect repair work when temperature and humidity conditions produce excessive evaporation of water from patching materials. Provide artificial shade and wind breaks, and use cooled materials as required. Do not apply to substrates with temperatures of 90 deg F (32 deg C) and above.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. For repair products, obtain each color, grade, finish, type, and variety of product from single source and from single manufacturer with resources to provide products of consistent quality in appearance and physical properties.

2.2 PATCHING MORTAR

- A. Patching Mortar Requirements:

1. Only use patching mortars that are recommended by manufacturer for each applicable horizontal, vertical, or overhead use orientation.
 2. Color and Aggregate Texture: Provide patching mortar and aggregates of colors and sizes necessary to produce patching mortar that matches existing, adjacent, and exposed concrete. Blend several aggregates if necessary to achieve suitable matches.
 3. Coarse Aggregate for Patching Mortar: ASTM C33/C33M, Size No. 8, Class 5S washed aggregate. Add to patching-mortar mix only as permitted by patching-mortar manufacturer.
- B. Rapid-Strengthening, Cementitious Patching Mortar : ASTM C928/C928M packaged, dry mix for repair of concrete.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Euclid Chemical Company; Euco-Speed MP or comparable product by one of the following:
 - a. ARDEX Americas
 - b. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
 - c. Sika Corporation
 - d. Sto Corp.
 2. Compressive Strength: Not less than 5000 psi (35 MPa) within three hours when tested in accordance with ASTM C109/C109M.

2.3 PREPLACED CONCRETE MATERIALS

- A. Preplaced Aggregate: Washed aggregate, ASTM C33/C33M, Class 5S, with 100 percent passing a 1-1/2-inch (38-mm) sieve, 95 to 100 percent passing a 1-inch (25-mm) sieve, 40 to 80 percent passing a 3/4-inch (19-mm) sieve, zero to 15 percent passing a 1/2-inch (12.7-mm) sieve, and zero to 2 percent passing a 3/8-inch (9.5-mm) sieve.

2.4 MISCELLANEOUS MATERIALS

- A. Curing Materials: For ready-mixed concrete or packaged repair materials.
- B. Formwork Materials: Form-facing materials must comply with ACI 301 (ACI 301M) requirements.
- C. Water: Potable.
- D. Cleaning Agent: Commercial muriatic acid solution.

2.5 MIXES

- A. General: Mix products, in clean containers, in accordance with manufacturer's written instructions.
1. Do not add water, thinners, or additives unless recommended by manufacturer.

2. When practical, use manufacturer's premeasured packages to ensure that materials are mixed in proper proportions. When premeasured packages are not used, measure ingredients using graduated measuring containers; do not estimate quantities or use shovel or trowel as unit of measure.
 3. Do not mix more materials than can be used within time limits recommended by manufacturer. Discard materials that have begun to set.
- B. Mortar Scrub Coat: Mix dry ingredients with enough water to provide consistency of thick cream.
- C. Dry-Pack Mortar: Mix required type(s) of patching-mortar dry ingredients with just enough liquid to form damp cohesive mixture that can be squeezed by hand into a ball but is not plastic.

PART 3 - EXECUTION

3.1 CONCRETE MAINTENANCE

- A. Have concrete-maintenance work performed only by qualified concrete-maintenance specialist.
- B. Comply with manufacturers' written instructions for surface preparation and product application.

3.2 EXAMINATION

- A. Notify Architect seven days in advance of dates when areas of deteriorated or delaminated concrete and deteriorated reinforcing bars will be located.
- B. Locate areas of deteriorated or delaminated concrete using hammer or chain-drag sounding and mark boundaries. Mark areas for removal by simplifying and squaring off boundaries. At columns and walls, make boundaries level and plumb unless otherwise indicated.
- C. Perform surveys as the Work progresses to detect hazards resulting from concrete-maintenance work.

3.3 PREPARATION

- A. Ensure that supervisory personnel are on-site and on duty when concrete-maintenance work begins and during its progress.
- B. Protect persons, motor vehicles, surrounding surfaces of building being repaired, building site, plants, and surrounding buildings from harm resulting from concrete-maintenance work.
 1. Comply with each product manufacturer's written instructions for protections and precautions. Protect against adverse effects of products and procedures on people and adjacent materials, components, and vegetation.
 2. Use only proven protection methods appropriate to each area and surface being protected.

3. Provide temporary barricades, barriers, and directional signage to exclude public from areas where concrete-maintenance work is being performed.
 4. Erect temporary protective covers over walkways and at points of pedestrian and vehicular entrance and exit that must remain in service during course of concrete-maintenance work.
 5. Contain dust and debris generated by concrete-maintenance work and prevent it from reaching the public or adjacent surfaces.
 6. Use water-mist sprinkling and other wet methods to control dust only with adequate, approved procedures and equipment that ensure that such water will not create a hazard or adversely affect other building areas or materials.
 7. Protect floors and other surfaces along haul routes from damage, wear, and staining.
 8. Protect adjacent surfaces and equipment by covering them with heavy polyethylene film and waterproof masking tape. If practical, remove items, store, and reinstall after potentially damaging operations are complete.
 9. Neutralize and collect alkaline and acid wastes for disposal off Owner's property.
 10. Dispose of debris and runoff from operations by legal means and in a manner that prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.
- C. Existing Drains: Prior to the start of concrete-maintenance work in an area, test drainage system to ensure that it is functioning properly. Notify Architect immediately of inadequate drainage or blockage. Do not begin concrete-maintenance work in an area until the drainage system is in working order.
1. Prevent solids, such as aggregate or mortar residue, from entering the drainage system. Clean out drains and drain lines that become sluggish or blocked by sand or other materials resulting from concrete-maintenance work.
 2. Protect drains from pollutants. Block drains or filter out sediments, allowing only clean water to pass.
- D. Preparation for Concrete Removal: Examine construction to be repaired to determine best methods to safely and effectively perform concrete-maintenance work. Examine adjacent work to determine what protective measures will be necessary. Make explorations, probes, and inquiries as necessary to determine condition of construction to be removed in the course of repair.
1. Verify that affected utilities have been disconnected and capped.
 2. Inventory and record the condition of items to be removed for reinstallation or salvage.
 3. Provide and maintain shoring, bracing, and temporary structural supports as required to preserve stability and prevent unexpected or uncontrolled movement, settlement, or collapse of construction being demolished and construction and finishes to remain. Strengthen or add new supports when required during progress of removal work.
- E. Reinforcing-Bar Preparation: Remove loose and flaking rust from exposed reinforcing bars by abrasive blast cleaning until only tightly adhered light rust remains.
1. Where section loss of reinforcing bar is more than 25 percent, or 20 percent in two or more adjacent bars, cut bars and remove and replace as indicated on Drawings.

2. Remove additional concrete as necessary to provide at least 3/4-inch (19-mm) clearance at existing and replacement bars.
3. Splice replacement bars to existing bars in accordance with ACI 318 (ACI 318M) by lapping, welding, or using mechanical couplings.

3.4 REMOVAL OF CONCRETE

- A. Do not overload structural elements with debris.
- B. Saw-cut perimeter of areas indicated for removal to a depth of at least 1/2 inch (13 mm). Make cuts perpendicular to concrete surfaces and no deeper than cover on reinforcement.
- C. Remove deteriorated and delaminated concrete by breaking up and dislodging from reinforcement.
- D. Remove additional concrete if necessary to provide a depth of removal of at least 1/2 inch (13 mm) over entire removal area.
- E. Where half or more of the perimeter of reinforcing bar is exposed, bond between reinforcing bar and surrounding concrete is broken, or reinforcing bar is corroded, remove concrete from entire perimeter of bar and to provide at least 3/4-inch (19-mm) clearance around bar.
- F. Test areas where concrete has been removed by tapping with hammer, and remove additional concrete until unsound and disbonded concrete is completely removed.
- G. Provide surfaces with a fractured profile of at least 1/8 inch (3 mm) that are approximately perpendicular or parallel to original concrete surfaces. At columns and walls, make top and bottom surfaces level unless otherwise directed.
- H. Thoroughly clean removal areas of loose concrete, dust, and debris.

I. INSTALLATION OF PATCHING MORTAR

- J. Place patching mortar as specified in this article unless otherwise recommended in writing by manufacturer.
 1. Provide forms where necessary to confine patch to required shape.
 2. Wet substrate and forms thoroughly and then remove standing water.
- K. General Placement: Place patching mortar by troweling toward edges of patch to force intimate contact with edge surfaces. For large patches, fill edges first and then work toward center, always troweling toward edges of patch. At fully exposed reinforcing bars, force patching mortar to fill space behind bars by compacting with trowel from sides of bars.
- L. Consolidation: After each lift is placed, consolidate material and screed surface.
- M. Multiple Lifts: Where multiple lifts are used, score surface of lifts to provide a rough surface for placing subsequent lifts. Allow each lift to reach final set before placing subsequent lifts.
- N. Finishing: Allow surfaces of lifts that are to remain exposed to become firm and then finish to a surface matching adjacent concrete.

- O. Curing: Wet-cure cementitious patching materials, including polymer-modified cementitious patching materials, for not less than seven days by water-fog spray or water-saturated absorptive cover.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Packaged, Cementitious Patching-Mortar Application: 3 randomly selected sets of samples for each type of mortar required, tested in accordance with ASTM C928/C928M.
2. Product will be considered defective if it does not pass tests and inspections.

B. Prepare test and inspection reports.

END OF SECTION 030130

SECTION 030140 – CLEANING OF PRECAST CONCRETE AND CURTAIN WALL PANELS

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes cleaning of existing concrete and curtain wall panels. as follows:
 - 1. Cleaning exposed, existing surfaces.
 - 2. Protection of existing structure during cleaning operations.

1.02 DEFINITIONS

- A. Cleaning: This Specification describes a cleaning system designed to effectively clean and restore the existing exterior [unit masonry][concrete][stone][curtain wall] surfaces. The system combines the application of a specific restorative cleaner with efficient rinsing pressure.
- B. Rinsing-Pressure Spray: 400 to 1000 psi; 6 to 8 gpm.
- C. Low-Pressure Spray: 100 to 400 psi; 4 to 6 gpm.

1.03 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 01 General Requirements specification sections.
- B. Product data for each product indicated including recommendations for their application and use. Include test reports and certifications substantiating that products comply with requirements.
- C. Material certificates for the following signed by manufacturer and Contractor certifying that each material complies with requirements.
 - 1. Each type of chemical cleaning material.
- D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include list of completed projects with project names, addresses, telephone numbers, names of Architects and Owners, and other information specified.
- E. Restoration program: For each phase of the restoration process, including protection of surrounding materials on building and site during operations. Describe in detail the materials, methods, and equipment to be used for each phase of the restoration work.
 - 1. If alternative methods and materials to those indicated are proposed for any phase of restoration work, provide a written description, including evidence of successful use on other comparable projects, and a testing program to demonstrate their effectiveness for this Project.
- F. Cleaning Program: Describe cleaning process in detail; protection of surrounding materials on building and site; and control of runoff during operations. Describe in detail the materials, methods and equipment to be used.
 - 1. If alternative methods and materials to those indicated are proposed for any phase of cleaning work, provide a written description, including evidence of successful use on other comparable projects, and a testing program to demonstrate their effectiveness for this Project.
- G. Cold-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with cold-weather requirements.

1.04 QUALITY ASSURANCE

- A. Restoration Specialist: Engage an experienced restoration and cleaning firm that has specialized in the types of work required for this Project for a minimum of five (5) years. At Contractor's option, the work may be divided between two specialist firms: one for cleaning work and one for repair work.
 - 1. Field Supervision: Require restoration specialist firm to maintain an experienced full-time supervisor on the job site during times that stone masonry restoration and cleaning are in progress.
 - 2. Restoration Worker Qualifications: Persons who are experienced in restoration work of types they will be performing.
- B. Chemical Manufacturer Qualifications: A company regularly engaged in producing cleaning compounds suitable for surfaces to be cleaned on site, which have been used on similar projects with successful results, and that retains factory-trained representatives who are available for consultation and job site inspection and assistance at no additional cost.
- C. Source of Materials: Obtain materials for restoration from a single source for each type material required (stone, cement, sand, etc.) to ensure a match of quality, color, pattern, and texture.
- D. Field-Constructed Mockups:
 - 1. Cleaning Mockup: Prior to starting general cleaning, prepare mockups on existing walls under same weather conditions to be expected during remainder of the Work. Prepare mockups using same materials, equipment, and methods proposed for the Work. Obtain Architect's acceptance of visual qualities before proceeding with work.
 - a. Notify Architect one week in advance of dates and times when samples will be prepared. Manufacturer's representative of cleaning materials to be present during testing.
 - b. Cleaning: Demonstrate the materials and methods to be used for cleaning each type of surface and condition on sample location approximately 25 sq. ft. in area.
 - 1) Test materials and methods on samples of adjacent non-masonry materials for possible reaction with cleaning materials, except where materials and methods are known to have a deleterious effect on such materials.
 - 2) Allow a waiting period of the duration indicated, but not less than 3 calendar days, after completion of sample cleaning to permit a study of sample panels for negative reactions.
 - c. Retain acceptable panels in an undisturbed condition, suitably marked, during construction as a standard for judging the completed Work. Areas may remain as part of the completed work.
 - d. Approval of sample panels is for degree of cleaning; aesthetic qualities of workmanship; and other material and construction qualities specifically approved by the Architect in writing.
 - 2. Approval of sample panels does not constitute approval of deviations from the Contract Documents contained in sample panels, unless such deviations are specifically approved by the Architect in writing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver masonry materials to Project in undamaged condition.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

1.06 PROJECT CONDITIONS

- A. Clean wall surfaces only when air temperature is 40 deg F and above and will remain so until wall has thawed and dried out, but for not less than 7 days after completion of cleaning.
 - 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F and above and will remain so until surface has thawed and dried out, but not less than 7 days after completion of cleaning.
 - 2. Hot-Weather Requirements: Protect work when temperature and humidity conditions produce excessive evaporation of water from surface. Provide artificial shade and wind breaks and use cooled materials as required.
 - a. Refer to chemical cleaner manufacturer's recommendations for application techniques when application hot-weather conditions exist.

1.07 SEQUENCING AND SCHEDULING

- A. Order replacement materials at earliest possible date, to avoid delaying completion of the Work.
- B. Perform restoration work in the following sequence:
 - 1. Remove plant growth, if any.
 - 2. Inspect for open mortar joints and repair before cleaning to prevent intrusion of water and other cleaning materials into the wall.
 - 3. Clean surfaces.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Substitutions: As approved by Architect.

2.02 CLEANING MATERIALS AND EQUIPMENT

- A. Water for Cleaning: Clean, potable, free of oils, acids, alkalis, salts, and organic matter.
- B. Low-odor, Non-fuming, Concentrated Restoration Cleaner: Manufacturer's standard concentrated acidic cleaner for cleaning atmospheric and carbon staining on concrete and cementitious panel wall surfaces.
 - 1. Basis-of-design Products:
 - a. "[Enviro Klean SafRestorer](#)": [PROSOCO, Inc.](#) (800-255-4255) (Basis of Design).
- C. Nonabrasive Brushes: Fiber bristles only.
- D. Spray Equipment: Provide equipment for controlled spray application of water and chemical cleaners, if any, at rates indicated for pressure, measured at spray tip, and for volume. Adjust pressure and volume, as required, to ensure that damage to surface does not result from cleaning methods.
 - 1. For chemical cleaner spray application, provide a low-pressure tank or chemical pump suitable for the chemical cleaner indicated, equipped with a cone-shaped spray tip.

2.03 CHEMICAL CLEANING SOLUTIONS

- A. General: Unless otherwise indicated, dilute chemical cleaning materials with water to produce solutions of concentration indicated but not greater than that recommended by chemical cleaner manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

3.02 PREPARATION

- A. General: Comply with the chemical cleaner manufacturer's recommendations for protecting adjacent building surfaces against damage from exposure to their products.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Protect persons, motor vehicles, surrounding surfaces of building whose surfaces are being restored, building site, plants, and surrounding buildings from injury resulting from work.
 - 1. Comply with chemical cleaner manufacturer's and Owner's written instructions for protecting building and other surfaces against damage from exposure to its products. Prevent chemical cleaning solutions from coming into contact with pedestrians, motor vehicles, landscaping, buildings, and other surfaces that could be injured by such contact.
 - 2. Cover adjacent surfaces with materials that are proven to resist chemical cleaners used unless chemical cleaners being used will not damage adjacent surfaces. Use materials that contain only waterproof, UV-resistant adhesives. Apply masking agents to comply with manufacturer's written instructions. Do not apply liquid masking agent to painted or porous surfaces. When no longer needed, promptly remove masking to prevent adhesive staining.
 - 3. Keep wall wet below area being cleaned to prevent streaking from runoff.
 - 4. Do not clean surfaces during winds of sufficient force to spread cleaning solutions to unprotected surfaces.
 - 5. Dispose of runoff from cleaning operations by legal means and in a manner that prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.
 - 6. Erect temporary protection covers over pedestrian walkways and at points of entrance and exit for persons and vehicles that must remain in operation during course of work.
- C. Protect adjacent surfaces from contact with chemical cleaners by covering them with a liquid strippable masking agent or polyethylene film and waterproof masking tape. Apply masking agent to comply with manufacturer's recommendations. Do not apply liquid masking agent to painted or porous surfaces.
 - 1. Contractor must provide detailed information on materials and method plan to be used on these surfaces, prior to beginning of work, and as approved by Architect.
- D. Surfaces that are not to be cleaned shall be protected from contact with the cleaning solution with sheets of polyethylene or other proven protective materials, firmly fixed and sealed to the surface.
 - 1. Contractor must provide detailed information on materials and method plan to be used on these surfaces, prior to beginning of work, and as approved by Architect.
- E. All surfaces not to be cleaned shall be tested for possible detrimental effect of the cleaning solutions and protected as determined necessary by test results.
- F. All open joints shall be temporarily caulked or otherwise protected to prevent intrusion of washing waters into the wall structure or building interior. Build up waterproof dams to divert flowing water to exterior.

3.03 ACIDIC CHEMICAL CLEANER

A. Low-odor, Non-fuming, Concentrated Restoration Cleaner :

1. At locations indicated, clean surfaces to comply with manufacturer's recommendations, as follows:
 - a. Prewet substrate with clean water applied working from bottom to the top.
 - b. Apply concentrate or diluted chemical cleaning system to prewet surfaces that comply with chemical cleaner manufacturer's written instructions for dilution and recommended application instructions; use low pressure spray, acid resistant brush, or heavy nap roller methods. Do not spray apply at pressures exceeding 50 psi.
 - c. Let the cleaning solution stay on the wall 5 to 15 minutes. If the cleaner starts to dry, reapply.
 - d. Reapply the cleaning solution to heavily soiled areas. Scrub gently.
 - e. Working from the bottom to the top, thoroughly rinse treated surfaces with clean water. Make sure to flush all spent cleaner and dissolved soiling from the surface, surface pores and adjacent surfaces.

3.04 PROTECTION

- A. Provide final protection and maintain conditions in a manner acceptable to Installer, which ensures work without damage and deterioration at the time of substantial completion.
- B. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.

END OF SECTION 03 01 40

SECTION 061000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wood products.
2. Fire-retardant-treated lumber.
3. Dimension lumber framing.

1.2 DEFINITIONS

- A. Dimension Lumber: Lumber of 2 inches nominal size or greater but less than 5 inches nominal size in least dimension.
- B. Lumber grading agencies, and abbreviations used to reference them, include the following:
1. NeLMA: Northeastern Lumber Manufacturers' Association.
 2. NLGA: National Lumber Grades Authority.
 3. SPIB: The Southern Pine Inspection Bureau.
 4. WCLIB: West Coast Lumber Inspection Bureau.
 5. WWPA: Western Wood Products Association.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
1. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
 2. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency in accordance with ASTM D5664.

1.4 INFORMATIONAL SUBMITTALS

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Stack wood products flat with spacers beneath and between each bundle to provide air circulation. Protect wood products from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS

- A. Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - 1. Factory mark each piece of lumber with grade stamp of grading agency.
 - 2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
 - 3. Dress lumber, S4S, unless otherwise indicated.
- B. Maximum Moisture Content:
 - 1. Boards: 15 percent.
 - 2. Dimension Lumber: 15 percent unless otherwise indicated.

2.2 FIRE-RETARDANT-TREATED LUMBER

- A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 - 1. Treatment is not to promote corrosion of metal fasteners.
 - 2. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering in accordance with ASTM D2898. Use for exterior locations and where indicated.
- C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent. Kiln-dry plywood after treatment to maximum moisture content of 15 percent.
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency and other information required by authorities having jurisdiction.
- E. Application: Treat all rough carpentry unless otherwise indicated.
 - 1. Concealed blocking.
 - 2. Wood cants, nailers, curbs, equipment support bases, blocking, and similar members in connection with roofing.

2.3 DIMENSION LUMBER FRAMING

- A. Non-Load-Bearing Interior Partitions by Grade: Construction or No. 2 grade.
- B. Species:
 - a. Hem-fir (north); NLGA.
 - b. Southern pine or mixed southern pine; SPIB.
 - c. Spruce-pine-fir; NLGA.
 - d. Hem-fir; WCLIB, or WWPA.
 - e. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.
 - f. Northern species; NLGA.
 - g. Eastern softwoods; NeLMA.
 - h. Western woods; WCLIB or WWPA.

2.4 MISCELLANEOUS LUMBER

- A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.
 - 2. Nailers.
 - 3. Rooftop equipment bases and support curbs.
- B. Dimension Lumber Items: Construction or No. 2 grade lumber of any of the following species:
 - 1. Hem-fir (north); NLGA.
 - 2. Mixed southern pine or southern pine; SPIB.
 - 3. Spruce-pine-fir; NLGA.
 - 4. Hem-fir; WCLIB or WWPA.
 - 5. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.
 - 6. Western woods; WCLIB or WWPA.
 - 7. Northern species; NLGA.
 - 8. Eastern softwoods; NeLMA.
- C. Roofing Nailers: Structural- or No. 2-grade lumber or better; kiln-dried Douglas fir, southern pine, or wood having similar decay-resistant properties.
- D. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

2.5 FASTENERS

- A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches into wood substrate.
 - 1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners of Type

304 stainless steel.

- B. Nails, Brads, and Staples: ASTM F1667.
- C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- D. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01, ICC-ES AC58, ICC-ES AC193, ICC-ES AC308 as appropriate for the substrate.

2.6 MISCELLANEOUS MATERIALS

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.
- B. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- C. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - 1. Table 2304.10.1, "Fastening Schedule," in ICC's International Building Code (IBC).
 - 2. ICC-ES evaluation report for fastener.
- D. Securely attach roofing nailers to substrates by anchoring and fastening to withstand bending, shear, or other stresses imparted by Project wind loads and fastener-resistance loads as designed in accordance with ASCE/SEI 7.
- E. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.2 INSTALLATION OF WOOD BLOCKING AND NAILERS

- A. Attach wood blocking to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

- B. Attach wood roofing nailers securely to substrate to resist the designed outward and upward wind loads indicated on Drawings and in accordance with ANSI/SPRI ED-1, Tables A6 and A7.

END OF SECTION 061000

SECTION 064116 - PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plastic-laminate-clad architectural cabinets.
2. Cabinet hardware and accessories.
3. Miscellaneous materials.

B. Related Requirements:

1. Section 061000 "Rough Carpentry" for wood furring, blocking, shims, and hanging strips required for installing cabinets that are concealed within other construction before cabinet installation.
2. Section 123661.16 "Solid Surfacing Countertops."

1.2 COORDINATION

- ##### A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to support loads imposed by installed and fully loaded cabinets.

1.3 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Show large-scale details.
3. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
4. Show locations and sizes of cutouts and holes for items installed in plastic-laminate architectural cabinets.

C. Samples: For each exposed product and for each color and texture specified, in manufacturer's or manufacturer's standard size.

1. Plastic Laminates: 8 by 10 inches (200 by 250 mm), for each type, color, pattern, and surface finish required.
 - a. Provide one sample applied to core material with specified edge material applied to one edge.
2. Exposed Cabinet Hardware and Accessories: One full-size unit for each type and finish.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer.
- B. Product Certificates: For each type of product.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver cabinets until painting and similar finish operations that might damage architectural cabinets have been completed in installation areas. Store cabinets in installation areas or in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.

1.7 FIELD CONDITIONS

- A. Environmental Limitations with Humidity Control: Do not deliver or install cabinets until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature between 60 and 90 deg F (16 and 32 deg C) and relative humidity between 25 and 55 percent during the remainder of the construction period.
- B. Field Measurements: Where cabinets are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 - 1. Locate concealed framing, blocking, and reinforcements that support cabinets by field measurements before being enclosed/concealed by construction, and indicate measurements on Shop Drawings.
- C. Established Dimensions: Where cabinets are indicated to fit to other construction, establish dimensions for areas where cabinets are to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

PART 2 - PRODUCTS

2.1 PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

- A. Quality Standard: Unless otherwise indicated, comply with the Architectural Woodwork Standards for grades of cabinets indicated for construction, finishes, installation, and other requirements.
- B. Architectural Woodwork Standards Grade: Custom.
- C. Type of Construction: Face frame.

- D. Door and Drawer-Front Style: Flush overlay.
- E. High-Pressure Decorative Laminate: ISO 4586-3, grades as indicated or if not indicated, as required by quality standard.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Wilsonart; as indicated on drawings, or comparable product by one of the following:
 - a. Formica Corporation
 - b. Pionite; a Panolam Industries International, Inc. brand
- F. Exposed Surfaces:
 - 1. Plastic-Laminate Grade: VGS.
 - 2. Edges: Grade VGS.
 - 3. Pattern Direction: Vertically for doors and fixed panels, horizontally for drawer fronts.
- G. Semiexposed Surfaces:
 - 1. Surfaces Other Than Drawer Bodies: High-pressure decorative laminate, ISO 4586-3.
 - a. Edges of Plastic-Laminate Shelves: PVC edge banding, 3.0 mm thick, matching laminate in color, pattern, and finish.
 - b. For semiexposed backs of panels with exposed plastic-laminate surfaces, provide surface of high-pressure decorative laminate, ISO 4586-3, grade to match exposed surface.
 - 2. Drawer Sides and Backs: Solid-hardwood lumber.
 - 3. Drawer Bottoms: Hardwood plywood.
- H. Dust Panels: 1/4-inch (6.4-mm) plywood or tempered hardboard above compartments and drawers unless located directly under tops.
- I. Concealed Backs of Panels with Exposed Plastic-Laminate Surfaces: High-pressure decorative laminate, ISO 4583-3, grade to match exposed surface.
- J. Drawer Construction: Fabricate with exposed fronts fastened to subfront with mounting screws from interior of body.
 - 1. Join subfronts, backs, and sides with glued rabbeted joints supplemented by mechanical fasteners.
- K. Colors, Patterns, and Finishes: Provide materials and products that result in colors and textures of exposed laminate surfaces complying with the following requirements:
 - 1. As selected by Architect from laminate manufacturer's full range in the following categories:
 - a. As selected by Architect from Manufacturer's full line.

2.2 WOOD MATERIALS

- A. Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of architectural cabinet and quality grade specified unless otherwise indicated.
 - 1. Wood Moisture Content: 5 to 10 percent.
- B. Composite Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of architectural cabinet and quality grade specified unless otherwise indicated.
 - 1. Medium-Density Fiberboard (MDF): ANSI A208.2, Grade 130.
 - 2. Particleboard (Medium Density): ANSI A208.1, Grade M-2.

2.3 CABINET HARDWARE AND ACCESSORIES

- A. Cabinet Hardware: Provide cabinet hardware and accessory materials associated with architectural cabinets.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide products as indicated on drawings or comparable product as approved by Architect.
- B. Drawer Slides: ANSI/BHMA A156.9.
 - 1. Heavy-Duty (Grade 1HD-100 and Grade 1HD-200): Side mount.
 - a. Type: Full extension.
 - b. Material: Zinc-plated ball bearing slides.
 - c. Motion Feature: Soft close dampener.
- C. Door Locks: ANSI/BHMA A156.11, E07121.
- D. Drawer Locks: ANSI/BHMA A156.11, E07041.
- E. Door and Drawer Silencers: ANSI/BHMA A156.16, L03011.
- F. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with ANSI/BHMA A156.18 for ANSI/BHMA finish number indicated, as indicated on drawings.
 - 1. Dark, Oxidized, Satin Bronze, Oil Rubbed: ANSI/BHMA 613 for bronze base; ANSI/BHMA 640 for steel base; match Architect's sample.
 - 2. Bright Brass, Clear Coated: ANSI/BHMA 605 for brass base; ANSI/BHMA 632 for steel base.
 - 3. Bright Brass, Vacuum Coated: ANSI/BHMA 723 for brass base; ANSI/BHMA 729 for zinc-coated-steel base.
 - 4. Satin Brass, Blackened, Bright Relieved, Clear Coated: ANSI/BHMA 610 for brass base; ANSI/BHMA 636 for steel base.
 - 5. Satin Chromium Plated: ANSI/BHMA 626 for brass or bronze base; ANSI/BHMA 652 for steel base.
 - 6. Bright Chromium Plated: ANSI/BHMA 625 for brass or bronze base; ANSI/BHMA 651 for steel base.
 - 7. Satin Stainless Steel: ANSI/BHMA 630.

- G. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in ANSI/BHMA A156.9.

2.4 MISCELLANEOUS MATERIALS

- A. Furring, Blocking, Shims, and Hanging Strips: Softwood or hardwood lumber, kiln-dried to less than 15 percent moisture content.
- B. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.
- C. Adhesive for Bonding Plastic Laminate: Type I, waterproof type as selected by fabricator to comply with requirements.
 - 1. Adhesive for Bonding Edges: Hot-melt adhesive or adhesive specified above for faces.

2.5 FABRICATION

- A. Fabricate architectural cabinets to dimensions, profiles, and details indicated.
- B. Complete fabrication, including assembly and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
- C. Shop-cut openings to maximum extent possible to receive hardware, appliances, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before installation, condition cabinets to humidity conditions in installation areas for not less than 72 hours.

3.2 INSTALLATION

- A. Architectural Woodwork Standards Grade: Install cabinets to comply with quality standard grade of item to be installed.
- B. Assemble cabinets and complete fabrication at Project site to extent that it was not completed in the shop.
- C. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Secure with wafer-head cabinet installation screws.

- D. Install cabinets level, plumb, and true in line to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm) using concealed shims.
 - 1. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
 - 2. Install cabinets without distortion so doors and drawers fit openings and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.
 - 3. Fasten wall cabinets through back, near top and bottom, and at ends not more than 16 inches (400 mm) o.c. with No. 10 wafer-head sheet metal screws through metal backing or metal framing behind wall finish.

3.3 ADJUSTING AND CLEANING

- A. Repair damaged and defective cabinets, where possible, to eliminate functional and visual defects. Where not possible to repair, replace architectural cabinets. Adjust joinery for uniform appearance.
- B. Clean, lubricate, and adjust hardware.
- C. Clean cabinets on exposed and semiexposed surfaces.

END OF SECTION 064116

SECTION 070150.19 - PREPARATION FOR REROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of This Section Includes:

1. Full roof tear-off.
2. Fastener pull-out testing.
3. Disposal.

1.2 DEFINITIONS

- A. Full Roof Tear-off: Removal of existing roofing system down to existing roof deck.
- B. Roofing Terminology: Definitions in ASTM D1079 and glossary of NRCA's "The NRCA Roofing Manual: Membrane Roof Systems" apply to work of this Section.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
1. Include certificate that Installer is approved by warrantor of existing roofing system.
 2. Include certificate that Installer is licensed to perform asbestos abatement.
- B. Field Test Reports: Fastener pull-out test report.
- C. Photographs or Video: Show existing conditions of adjoining construction and site improvements, including exterior and interior finish surfaces, that might be misconstrued as having been damaged by reroofing operations.
1. Submit before Work begins.
- D. Landfill Records: Indicate receipt and acceptance of demolished roofing materials and hazardous wastes, such as asbestos-containing materials, by a landfill facility licensed to accept them.

1.5 CLOSEOUT SUBMITTALS

- A. Certified statement from Firestone Building Products stating that existing roof warranty has not been affected by Work performed under this Section.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Approved by warrantor of existing roofing system to work on existing roofing, licensed to perform asbestos abatement in the state or jurisdiction where Project is located.
- B. Regulatory Requirements:
 - 1. Comply with governing EPA notification regulations before beginning roofing removal.
 - 2. Comply with hauling and disposal regulations of authorities having jurisdiction.

1.7 FIELD CONDITIONS

- A. Existing Roofing System: PVC roofing.
- B. Owner will occupy portions of building immediately below reroofing area.
 - 1. Conduct reroofing so Owner's operations are not disrupted.
 - 2. Provide Owner with not less than 72 hours' written notice of activities that may affect Owner's operations.
 - 3. Coordinate work activities daily with Owner so Owner has adequate advance notice to place protective dust and water-leakage covers over sensitive equipment and furnishings, shut down HVAC and fire-alarm or -detection equipment if needed, and evacuate occupants from below work area.
- C. Protect building to be reroofed, adjacent buildings, walkways, site improvements, exterior plantings, and landscaping from damage or soiling from reroofing operations.
- D. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities.
- E. Conditions existing at time of inspection for bidding will be maintained by Owner as far as practical.
- F. Weather Limitations: Proceed with reroofing preparation only when existing and forecasted weather conditions permit Work to proceed without water entering existing roofing system or building.
 - 1. Remove only as much roofing in one day as can be made watertight in the same day.
- G. Hazardous Materials:
 - 1. A report on the presence of hazardous materials is attached to the project manual

for reference. . Examine report to become aware of locations where hazardous materials are present for abatement.

- a. Hazardous material remediation is specified elsewhere in the Contract Documents.
- b. Coordinate reroofing preparation with hazardous material remediation to prevent water from entering existing roofing system or building.

1.8 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during reroofing, by methods and with materials so as not to void existing roofing system warranty issued by Firestone Building Products.
 1. Notify warrantor before proceeding with the Work.
 2. Notify warrantor of existing roofing system on completion of reroofing, and obtain documentation verifying that existing roofing system has been inspected and warranty remains in effect.
 - a. Submit documentation at Project closeout.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection of In-Place Conditions:
 1. Protect existing roofing system that is not to be reroofed.
 2. Limit traffic and material storage to areas of existing roofing that have been protected.
 3. Maintain temporary protection and leave in place until replacement roofing has been completed. Remove temporary protection on completion of reroofing.
 4. Comply with requirements of existing roof system manufacturer's warranty requirements.
- B. Seal or isolate windows that may be exposed to airborne substances created in removal of existing materials.
- C. Shut off rooftop utilities and service piping before beginning the Work.
- D. Test existing roof drains to verify that they are not blocked or restricted per drawings.
- E. Coordinate with Owner to shut down air-intake equipment in the vicinity of the Work.
 1. Cover air-intake louvers before proceeding with reroofing work that could affect indoor air quality or activate smoke detectors in the ductwork.
- F. During removal operations, have sufficient and suitable materials on-site to facilitate

rapid installation of temporary protection in the event of unexpected rain.

- G. Maintain roof drains in functioning condition to ensure roof drainage at end of each workday.
 - 1. Prevent debris from entering or blocking roof drains and conductors.
 - a. Use roof-drain plugs specifically designed for this purpose.
 - b. Remove roof-drain plugs at end of each workday, when no work is taking place, or when rain is forecast.
 - 2. If roof drains are temporarily blocked or unserviceable due to roofing system removal or partial installation of new roofing system, provide alternative drainage method to remove water and eliminate ponding.
 - a. Do not permit water to enter into or under existing roofing system components that are to remain.

3.2 ROOF TEAR-OFF

- A. Lower removed roofing materials to ground and onto lower roof levels, using dust-tight chutes or other acceptable means of removing materials from roof areas.
- B. Remove pavers and accessories from roofing.
- C. Full Roof Tear-off: Where indicated on Drawings, remove existing roofing and other roofing system components down to the existing roof deck.
 - 1. Remove substrate board, vapor retarder, roof insulation, and, cover board.
 - 2. Remove base flashings and counter flashings.
 - 3. Remove perimeter edge flashing and gravel stops.
 - 4. Remove copings.
 - 5. Remove expansion-joint covers.
 - 6. Remove flashings at pipes, curbs, mechanical equipment, and other penetrations.
 - 7. Remove wood blocking, curbs, and nailers.
 - 8. Bitumen and felts that are firmly bonded to concrete decks are permitted to remain if felts are dry.
 - a. Remove unadhered bitumen, unadhered felts, and wet felts.
 - 9. Remove fasteners from deck or cut fasteners off slightly above deck surface.

3.3 DECK PREPARATION

- A. Inspect deck after tear-off of roofing system.
- B. If broken or loose fasteners that secure deck panels to one another or to structure are observed, or if deck appears or feels inadequately attached, immediately notify Architect.
 - 1. Do not proceed with installation until directed by Architect.

- C. If deck surface is unsuitable for receiving new roofing or if structural integrity of deck is suspect, immediately notify Architect.

- 1. Do not proceed with installation until directed by Architect.

3.4 FASTENER PULL-OUT TESTING

- A. Perform fastener pull-out tests according to SPRI FX-1, and submit test report to Architect, and, roofing manufacturer before installing new roofing system.

- 1. Obtain roofing manufacturer's approval to proceed with specified fastening pattern.

3.5 DISPOSAL

- A. Collect demolished materials and place in containers.

- 1. Promptly dispose of demolished materials.
 - 2. Do not allow demolished materials to accumulate on-site.
 - 3. Storage or sale of demolished items or materials on-site is not permitted.

- B. Transport and legally dispose of demolished materials off Owner's property.

END OF SECTION 070150.19

SECTION 075419 - POLYVINYL-CHLORIDE (PVC) ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Polyvinyl chloride (PVC) roofing system.
2. Accessory roofing system materials.
3. Vapor retarder.
4. Roof insulation and accessories.
5. Cover board.

B. Related Requirements:

1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking; and for wood-based, structural-use roof deck panels.
2. Section 077100 "Roof Specialties" for roof edge fasciae.
3. Section 079200 "Joint Sealants" for joint sealants, joint fillers, and joint preparation.

1.2 DEFINITIONS

- ##### A. Roofing Terminology: Definitions in ASTM D1079 and glossary in NRCA's "Roofing Manual: Membrane Roof Systems" apply to Work of this Section.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings: Include roof plans, sections, details, and attachments to other work, including the following:

1. Layout and thickness of insulation.
2. Base and sheet flashings and membrane termination details.
3. Flashing details at penetrations.
4. Tapered insulation layout, thickness, and slopes.
5. Roof plan showing orientation of roof deck and orientation of roofing membrane, fastening spacings, and patterns for corner, perimeter, and field-of-roof locations.
6. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
7. Crickets, saddles, and tapered edge strips, including slopes.
8. Tie-in with adjoining wall system air barrier.

C. Samples for Verification: For the following products:

1. Roofing membrane and flashings, of color required.
- D. Wind-Uplift-Resistance Submittal: For roofing system, indicating compliance with wind-uplift performance requirements.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer Certificates:
 1. Performance Requirement Certificate: Signed by roofing membrane manufacturer, certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with specified performance requirements.
 2. Special Warranty Certificate: Signed by roofing membrane manufacturer, certifying that all materials supplied under this Section are acceptable for special warranty.
- B. Product Test Reports: For roofing membrane and insulation, tests performed by an independent qualified testing agency indicating compliance with specified requirements.
- C. Research Reports: For components of roofing system, from ICC-ES showing compliance with specified performance requirements.
- D. Field Test Reports:
 1. Concrete internal relative humidity test reports.
 2. Fastener-pullout test results and manufacturer's revised requirements for fastener patterns.
- E. Field quality-control reports.
- F. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For roofing system.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer that is listed in SPRI's "Directory of Roof Assemblies" for roofing system identical to that used for this Project.
- B. Installer Qualifications: A qualified firm that is approved, authorized, certified, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver roofing system materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
- B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer.
 - 1. Protect stored liquid material from direct sunlight.
 - 2. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
- C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources.
 - 1. Store in a dry location.
 - 2. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
- D. Handle and store roofing system materials, and place equipment in a manner to avoid permanent deflection of deck.

1.8 FIELD CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed in accordance with manufacturer's written installation instructions and warranty requirements.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.
 - 1. Special warranty to include all components of roofing system, such as vapor retarder, roof insulation, fasteners, adhesives, cover board, roofing membrane, base flashing sheet, and other components of roofing system.
 - 2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Installed roofing system and flashings to withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing system and flashings to remain watertight.
 - 1. Accelerated Weathering: Roofing membrane to withstand 2000 hours of exposure when tested in accordance with ASTM G152, ASTM G154, or ASTM G155.

2. Impact Resistance: Roofing membrane to resist impact damage when tested in accordance with ASTM D3746/D3746M, ASTM D4272/D4272M, or the Resistance to Foot Traffic Test in FM Approvals 4470.
- B. Material Compatibility: Roofing system materials to be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roofing membrane manufacturer based on testing and field experience.
 - C. Wind-Uplift Resistance: Design roofing system to resist the following wind-uplift pressures when tested in accordance with FM Approvals 4474, UL 580, or UL 1897:
 1. Zone 1' (Roof Area Interior): <Insert **lbf/sq. ft. (kPa)**>.
 2. Zone 1 (Roof Area Field): <Insert **lbf/sq. ft. (kPa)**>.
 3. Zone 2 (Roof Area Perimeter): <Insert **lbf/sq. ft. (kPa)**>.
 - a. Location: From roof edge to <Insert **dimension**> inside roof edge.
 4. Zone 3 (Roof Area Corners): <Insert **lbf/sq. ft. (kPa)**>.
 - a. Location: <Insert **dimension**> in each direction from building corner.
 - D. Exterior Fire-Test Exposure: Class A; for application and roof slopes indicated; when tested by a qualified testing agency in accordance with ASTM E108 or UL 790.
 1. Identify products with appropriate markings of applicable testing agency.
- ## 2.2 POLYVINYL CHLORIDE (PVC) ROOFING SYSTEM
- A. PVC Roofing Membrane Sheet: ASTM D4434/D4434M, fabric reinforced.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carlisle Syntec Systems
 - b. Johns Manville; a Berkshire Hathaway company
 - c. Sika Sarnafil
 - d. Versico Roofing Systems; Carlisle Construction Materials
 2. Classification: Type II.
 3. Nominal Thickness: **60 mil (1.5 mm)**.
 4. Exposed Face Color: White.
- ## 2.3 ACCESSORY ROOFING SYSTEM MATERIALS
- A. General: Accessory materials as recommended in writing by roofing membrane manufacturer for intended use and compatible with other roofing system components.
 1. Adhesives and Sealants: Comply with VOC limits of authorities having jurisdiction.

- B. Base and Sheet Flashings: Manufacturer's standard sheet flashing of same material, type, reinforcement, thickness, and color as roofing membrane.
- C. Prefabricated Pipe Flashings: As recommended in writing by roofing membrane manufacturer.
- D. Roof Vents: As recommended in writing by roofing membrane manufacturer.
 - 1. Size: Not less than **4-inch (100-mm)** diameter.
- E. Bonding Adhesive: Roofing membrane manufacturer's standard.
- F. Slip Sheet: Manufacturer's standard, of thickness required for application.
- G. Metal Termination Bars: Manufacturer's standard, predrilled stainless steel or aluminum bars, approximately **1 by 1/8 inch (25 by 3 mm)** thick; with anchors.
- H. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roofing system components to substrate, tested for required pullout strength, and acceptable to roofing membrane manufacturer.
- I. Safety Accessories: Roofing membrane manufacturer's standard yellow seaming tape for designating safety perimeters and rooftop hazards.
- J. Miscellaneous Accessories: As recommended in writing by roofing membrane manufacturer.

2.4 VAPOR RETARDER

- A. Rubberized-Asphalt-Sheet Vapor Retarder, Self-Adhering: ASTM D1970/D1970M, polyethylene film laminated to layer of rubberized asphalt adhesive, minimum **40-mil (1.0-mm)** total thickness; maximum permeance rating of **0.1 perm (6 ng/Pa x s x sq. m)**; cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor retarder manufacturer.
- B. Butyl-Rubber-Sheet Vapor Retarder, Self-Adhering: Polyethylene film laminated to layer of butyl rubber adhesive, minimum **30-mil (0.76-mm)** total thickness; maximum permeance rating of **0.1 perm (6 ng/Pa x s x sq. m)**; cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor retarder manufacturer.
- C. Laminated Sheet Vapor Retarder: Two layers; fire-retardant polyethylene laminate; reinforced with cord grid.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Reef Industries, Inc.
 - 2. Permeance Rating: Not more than **0.062 perm (3.556 ng/Pa x s x sq. m)** when tested in accordance with ASTM E96/E96M.
 - 3. Flame-Spread Index: Not more than 5 when tested in accordance with ASTM E84.

4. Smoke-Developed Index: Not more than 35 when tested in accordance with ASTM E84.
5. Tape: Pressure-sensitive tape of type recommended by vapor retarder manufacturer for sealing joints and penetrations in vapor retarder.

2.5 ROOF INSULATION AND ACCESSORIES

- A. General: Preformed roof insulation boards manufactured or approved by roofing membrane manufacturer approved for use in SPRI's "Directory of Roof Assemblies" listed roof assemblies.
- B. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 1, Grade 2, felt or glass-fiber mat facer on both major surfaces.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carlisle Syntec Systems
 - b. CertainTeed; SAINT-GOBAIN
 - c. Insulfoam; a Carlisle Company
 - d. Johns Manville; a Berkshire Hathaway company
 2. Compressive Strength: Grade 2, 20 psi (138 kPa).
 3. Size: 48 by 96 inches (1200 by 2400 mm).
 4. Thickness:
 - a. At least Two layers totaling minimum 4.5" to achieve a maximum area weighted average U-factor of U-0.032, inclusive of tapered insulation layer.

2.6 COVER BOARD

- A. General: Cover board as recommended in writing by roofing membrane manufacturer for intended use and compatible with other roofing system components.
- B. Glass-Mat Gypsum Cover Board: ASTM C1177/C1177M, water-resistant gypsum board.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed; SAINT-GOBAIN
 - b. Georgia-Pacific Gypsum LLC
 - c. Gold Bond Building Products, LLC provided by National Gypsum Company
 - d. USG Corporation
 2. Thickness: 5/8 inch (16 mm).
 3. Surface Finish: Fiberglass facer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Roofing System Installer present, for compliance with requirements and other conditions affecting performance of the Work.
 - 1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
 - 2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - 3. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
 - 4. Verify that concrete substrate is visibly dry and free of moisture, and that minimum concrete internal relative humidity is not more than 75 percent, or as recommended by roofing system manufacturer, when tested in accordance with ASTM F2170.
 - a. Test Frequency: One test probe per each 1000 sq. ft. (93 sq. m), or portion thereof, of roof deck, with no fewer than three test probes.
 - b. Submit test reports within 24 hours of performing tests.
 - 5. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.
 - 6. Verify that joints in precast concrete roof decks have been grouted flush with top of concrete.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing system installation in accordance with roofing system manufacturer's written instructions. Remove sharp projections.
- B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
- C. Prime surface of concrete deck with primer in accordance with roofing system manufacturer's written installation instructions and allow primer to dry.
- D. Perform fastener-pullout tests in accordance with roofing system manufacturer's written instructions.
 - 1. Submit test result within 24 hours of performing tests.
 - a. Include manufacturer's requirements for any revision to previously submitted fastener patterns required to achieve specified wind uplift requirements.

3.3 INSTALLATION OF POLYVINYL-CHLORIDE (PVC) ROOFING SYSTEM, GENERAL

- A. Install roofing system materials and components in accordance with roofing system manufacturer's written installation instructions, SPRI's "Directory of Roof Assemblies" listed roof assembly requirements, and FM Global Property Loss Prevention Data Sheet 1-29.
- B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at end of workday or when rain is forecast. Remove and discard temporary seals before beginning Work on adjoining roofing.

3.4 INSTALLATION OF VAPOR RETARDER

- A. Install vapor retarder in a single layer over roof area in accordance with manufacturer's written installation instructions, side and end lapping each sheet a minimum of **2 and 6 inches (50 and 150 mm)**, respectively.
 - 1. Extend vertically up parapet walls and projections to a minimum height equal to height of insulation and cover board.
 - 2. Continuously seal side and end laps with tape.
- B. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into roofing system.

3.5 INSTALLATION OF ROOF INSULATION AND ACCESSORIES

- A. Coordinate installation of roofing system components so insulation is not exposed to precipitation or left exposed at end of workday.
- B. Comply with roofing system and insulation manufacturer's written installation instructions. Install minimum of two layers of insulation under area of roofing to achieve required thickness.
- C. Install each layer of insulation with joints staggered not less than **24 inches (600 mm)** in adjacent rows and offset not less than **12 inches (300 mm)** from previous layer.
 - 1. Trim insulation neatly to fit around penetrations and projections, and to fit tightly to intersecting sloping roof decks.
 - 2. Make joints between adjacent insulation boards not more than **1/4 inch (6 mm)** in width.
 - 3. At internal roof drains, slope insulation to create a square drain sump, with each side equal to the diameter of the drain bowl plus **24 inches (600 mm)**.
 - 4. Trim insulation, so that water flow is unrestricted.
 - 5. Fill gaps exceeding **1/4 inch (6 mm)** with insulation.
 - 6. Cut and fit insulation within **1/4 inch (6 mm)** of nailers, projections, and penetrations.
 - 7. Secure insulation to resist specified uplift pressure at corners, perimeter, and field of roof.

3.6 INSTALLATION OF COVER BOARD

- A. Install cover board over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of **6 inches (150 mm)** in each direction.
 - 1. Trim cover board neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - 2. At internal roof drains, conform to slope of drain sump.

- a. Trim cover board so that water flow is unrestricted.
- 3. Cut and fit cover board tight to nailers, projections, and penetrations.
- B. Install slip sheet over cover board and immediately beneath roofing membrane.
- C. Place plates on cover board in required fastening patterns and secure in accordance with roofing system manufacturer's written installation instructions.
 - 1. Install plates and fasteners tight and flat to substrate with no dimpling, and with fastener extending **1 inch (25 mm)** minimum into roof deck; do not overdrive fasteners.
- 3.7 INSTALLATION OF PVC ROOFING MEMBRANE
 - A. Install roofing membrane over roof area for adhered application method in accordance with roofing system manufacturer's written installation instructions.
 - B. Unroll roofing membrane and allow it to relax before installing.
 - C. Start installation in presence of roofing system manufacturer's technical personnel.
 - D. Accurately align roofing membrane and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps. Apply roofing membrane with side laps shingled with slope of roof deck where possible.
 - E. Adhered Application: Apply bonding adhesive to substrate and underside of roofing membrane at rate required by manufacturer and allow to partially dry before installing roofing membrane. Do not apply to splice area of roofing membrane.
 - 1. In addition to adhering, mechanically fasten roofing membrane securely at terminations, penetrations, and perimeter of roofing.
 - F. Seams and End Laps: Clean seam areas, overlap membrane, and hot-air-weld side seams and end laps of roofing membrane and sheet flashing to ensure a watertight installation.
 - 1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of roofing membrane and sheet flashings.
 - 2. Verify field strength of seams a minimum of twice daily, and repair seam sample areas.
 - 3. Repair tears, voids, and lapped seams in roofing membrane that do not comply with requirements.
 - G. Spread sealant bed over deck-drain flange at roof drains, and securely seal roof membrane in place with clamping ring.
- 3.8 INSTALLATION OF BASE AND SHEET FLASHINGS
 - A. General: Install and adhere base and sheet flashings and preformed flashing accessories to substrates in accordance with roofing system manufacturer's written installation instructions.
 - B. Apply bonding adhesive to substrate and underside of flashings at required rate and allow to

partially dry. Do not apply to seam area of flashing.

- C. Flash penetrations and field-formed inside and outside corners.
- D. Clean seam areas, overlap, and firmly roll flashings into the adhesive. Hot-air-weld side seams and end laps to ensure a watertight installation.
- E. Terminate and seal top of flashings and mechanically anchor to substrate through termination bars.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspect substrate conditions, surface preparation, and application of roofing membrane, flashings, protection, and drainage components, and to furnish reports to Architect.
- B. Perform the following tests:
 - 1. ELD Testing: Testing agency surveys entire roof area and flashings to locate discontinuities in the roofing membrane using ELD in accordance with ASTM D7877 and ASTM D8231.
 - a. After testing, repair areas of discontinuities, repeat tests, and make further repairs until roofing and flashing installations are contiguous.
 - 1) Cost of retesting is Contractor's responsibility.
 - b. Testing agency to prepare survey report indicating locations of initial discontinuities, if any.
- C. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion, in presence of Architect, and to prepare inspection report.
 - 1. Notify Architect and Owner 48 hours in advance of date and time of inspection.
- D. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.10 PROTECTING AND CLEANING

- A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing system for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.
- B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and in accordance with warranty requirements.

3.11 ROOFING SYSTEM INSTALLER'S WARRANTY

- A. WHEREAS _____ of _____, herein called the "Roofing System Installer," has performed roofing and associated Work on the following Project:
1. Owner: **<Insert name of Owner>**.
 2. Owner Address: **<Insert address>**.
 3. Building Name/Type: **<Insert information>**.
 4. Building Address: **<Insert address>**.
 5. Area of Work: **<Insert information>**.
 6. Acceptance Date: _____.
 7. Warranty Period: [**Two**] [**Five**] **<Insert number>** years from date of Substantial Completion.
 8. Date of Substantial Completion: _____.
- B. AND WHEREAS Roofing System Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant said Work against leaks and faulty or defective materials and workmanship for designated Warranty Period,
- C. NOW THEREFORE Roofing System Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period Roofing Installer will, at Roofing System Installer's own cost and expense, make or cause to be made such repairs to or replacements of said Work as are necessary to correct faulty and defective work and as are necessary to maintain said Work in a watertight condition.
- D. This Warranty is made subject to the following terms and conditions:
1. Specifically excluded from this Warranty are damages to Work and other parts of the building, and to building contents, caused by:
 - a. lightning;
 - b. peak gust wind speed exceeding **<Insert mph (m/s)>**;
 - c. fire;
 - d. failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;
 - e. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the Work;
 - f. vapor condensation on bottom of roofing; and
 - g. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.
 2. When Work has been damaged by any of foregoing causes, Warranty will be null and void until such damage has been repaired by Roofing System Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.
 3. Roofing System Installer is responsible for damage to Work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of Work.
 4. During Warranty Period, if Owner allows alteration of Work by anyone other than Roofing System Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this

Warranty will become null and void on date of said alterations, but only to the extent said alterations affect Work covered by this Warranty. If Owner engages Roofing System Installer to perform said alterations, Warranty will not become null and void unless Roofing System Installer, before starting said Work, will have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate Work, thereby reasonably justifying a limitation or termination of this Warranty.

5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty will become null and void on date of said change, but only to the extent said change affects Work covered by this Warranty.
6. Owner will promptly notify Roofing System Installer of observed, known, or suspected leaks, defects, or deterioration and afford reasonable opportunity for Roofing System Installer to inspect Work and to examine evidence of such leaks, defects, or deterioration.
7. This Warranty is recognized to be the only warranty of Roofing System Installer on said Work and will not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty will not operate to relieve Roofing System Installer of responsibility for performance of original Work in accordance with requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

E. IN WITNESS THEREOF, this instrument has been duly executed this _____ day of _____, _____.

1. Authorized Signature: _____.
2. Name: _____.
3. Title: _____.

END OF SECTION 075419

SECTION 077100 - ROOF SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Manufactured units for the following applications:
 - 1. Roof-edge specialties.
- B. Related Requirements:
 - 1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking.
 - 2. Section 076200 "Sheet Metal Flashing and Trim" for custom- and site-fabricated, sheet metal flashing and trim.
 - 3. Section 077200 "Roof Accessories" for manufactured roof curbs, equipment supports, roof hatches, vents, and other manufactured roof accessory units.
 - 4. Section 079200 "Joint Sealants" for field-applied sealants between roof specialties and adjacent materials.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of roof specialty.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Shop Drawings: For roof specialties.
 - 1. Plans, expansion-joint locations, keyed details, and attachments to other work. Distinguish between factory pre manufactured- and field-assembled installation.
 - 2. Details for expansion and contraction; locations of expansion joints, including direction of expansion and contraction.
 - 3. Indicate profile and pattern of seams and layout of fasteners, cleats, clips, and other attachments.
 - 4. Details of termination points and assemblies, including fixed points.
 - 5. Details of special conditions.
- C. Samples: For each type of roof specialty and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of roof specialty roof-edge flashings that is ANSI/SPRI/FM 4435/ES-1 tested.
- B. Product Test Reports: For roof-edge flashings, for tests performed by a qualified testing agency.
- C. Research Reports: For roof-edge flashings, from ICC-ES showing compliance with ANSI/SPRI/FM 4435/ES-1.

- D. Qualification Statements: For manufacturer.
- E. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For roof specialties.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer offering products that are ANSI/SPRI/FM 4435/ES-1 tested to specified design pressure.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store roof specialties in contact with other materials that might cause staining, denting, or other surface damage. Store roof specialties away from uncured concrete and masonry.
- B. Protect strippable protective covering on roof specialties from exposure to sunlight and high humidity, except to extent necessary for the period of roof-specialty installation.

1.7 FIELD CONDITIONS

- A. Field Measurements: Verify profiles and tolerances of roof-specialty substrates by field measurements before fabrication, and indicate measurements on Shop Drawings.

1.8 COORDINATION

- A. Coordinate roof specialties with roofing system, exterior wall system, air barrier, flashing, trim, and construction of parapets, roof deck, roof and wall panels, and other adjoining work to provide a leakproof, weathertight, secure, and noncorrosive installation.
 - 1. Performance Coordination: Coordinate with the Work of roofing and exterior wall Sections to ensure that roof specialties provided under the Work of this Section meet or exceed specified roofing and exterior wall design performance requirements.
- B. Confirm and coordinate compatibility of materials and comply with warranty requirements of roofing system manufacturer.
- C. Coordinate roof specialties layout and seams with sizes and locations of joints and seams in adjacent materials.

1.9 WARRANTY

- A. Roofing-System Warranty: Roof specialties are included in warranty provisions in Section 075419, "Polyvinyl-chloride (PVC) Roofing."

- B. Special Warranty on Painted Finishes: Manufacturer agrees to repair finishes or replace roof specialties that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain roof specialties from single manufacturer providing roofing-system warranty specified in Section 075419, "Polyvinyl-chloride (PVC) Roofing."

2.2 PERFORMANCE REQUIREMENTS

- A. General Performance: Roof specialties to withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
- B. SPRI Wind Design Standard: Manufacture and install roof-edge specialties tested in accordance with ANSI/SPRI/FM 4435/ES-1 and capable of resisting the following design pressures:
 - 1. Design Pressure: [As indicated on Drawings] .
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, hole elongation, over stressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Provide clips that resist rotation and avoid shear stress as a result of thermal movements. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.3 ROOF-EDGE SPECIALTIES

- A. Canted Roof-Edge Fascia and Gravel Stop : Manufactured, two-piece, roof-edge fascia consisting of snap-on metal fascia cover in section lengths not exceeding 12 ft. (3.6 m) and a continuous formed galvanized-steel sheet cant, 0.028 inch (0.71 mm) thick, minimum, with extended vertical leg terminating in a drip-edge cleat. Provide matching corner units.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Carlisle; SecurEdge 2000 or comparable product by one of the following:
 - a. ATAS International, Inc.
 - b. Englert, Inc.
 - c. PAC-CLAD; Petersen; a Carlisle company
 - d. SAF (Southern Aluminum Finishing Company, Inc.)
 2. Extruded-Aluminum Fascia Covers: Extruded aluminum, thickness as required to meet performance requirements.
 - a. Finish: Two-coat fluoropolymer.
 - b. Color: As selected by Architect from manufacturer's full range.
 3. Corners: Factory mitered and continuously welded.
 4. Splice Plates: Concealed, of same material, finish, and shape as fascia cover.
 5. Fascia Accessories: Fascia extenders with continuous hold-down cleats.
- B. Roof-Edge Fascia: Manufactured, two-piece, roof-edge fascia consisting of snap-on metal fascia cover in section lengths not exceeding 12 ft. (3.6 m) and a continuous metal receiver with integral drip-edge cleat to engage fascia cover and secure single-ply roof membrane. Provide matching corner units.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Carlisle; SecurEdge 2000 or comparable product by one of the following:
 - a. ATAS International, Inc.
 - b. Englert, Inc.
 2. Extruded-Aluminum Fascia Covers: Extruded aluminum, thickness as required to meet performance requirements.
 - a. Finish: Two-coat fluoropolymer.
 - b. Color: As selected by Architect from manufacturer's full range.
 3. Corners: Factory mitered and continuously welded.
 4. Splice Plates: Concealed, of same material, finish, and shape as fascia cover.
 5. Receiver: Extruded aluminum, 0.080 inch (2.03 mm) thick.
 6. Fascia Accessories: Fascia extenders with continuous hold-down cleats.

2.4 SHEET METAL MATERIALS

- A. Aluminum Sheet: ASTM B209/B209M, manufacturer's standard alloy for finish required, with temper to suit forming operations and performance required.
1. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A755/A755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Two-Coat Fluoropolymer Finish: AAMA 2605. System consisting of primer and

fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight in color coat.

- B. Aluminum Extrusions and Tubes: ASTM B221 (ASTM B221M), manufacturer's standard alloy and temper for type of use, finished to match assembly where used; otherwise, mill finished.

2.5 MISCELLANEOUS MATERIALS

- A. Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.
- B. Fasteners: Roof specialty manufacturer's recommended fasteners, designed to meet performance requirements, suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners. Furnish the following unless otherwise indicated:
 - 1. Fasteners for Metallic-Coated Steel Sheet: Series 300 stainless steel or hot-dip zinc-coated steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M.
 - 2. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
 - 3. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.
- C. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.
- D. Elastomeric Sealant: ASTM C920, elastomeric siliconopolymer sealant of type, grade, class, and use classifications required by roofing-specialty manufacturer for each application.
- E. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type joints with limited movement.
- F. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.6 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM/NOMMA AMP 500, "Metal Finishes Manual for Architectural and Metal Products," for recommendations for applying and designating finishes.
- B. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.

- B. Examine walls, roof edges, and parapets for suitable conditions for roof specialties.
- C. Verify that substrate is sound, dry, smooth, clean, sloped for drainage where applicable, and securely anchored.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install roof specialties in accordance with manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, underlayments, sealants, and other miscellaneous items as required to complete roof-specialty systems.
 - 1. Install roof specialties level, plumb, true to line and elevation; with limited oil-canning and without warping, jogs in alignment, buckling, or tool marks.
 - 2. Provide uniform, neat seams with minimum exposure of solder and sealant.
 - 3. Install roof specialties to fit substrates and to result in weathertight performance. Verify shapes and dimensions of surfaces to be covered before manufacture.
 - 4. Torch cutting of roof specialties is not permitted.
 - 5. Do not use graphite pencils to mark metal surfaces.
- B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer's written installation instructions.
 - 1. Coat concealed side of uncoated aluminum and stainless steel roof specialties with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - 2. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof specialties for waterproof performance.
- C. Expansion Provisions: Allow for thermal expansion of exposed roof specialties.
 - 1. Space movement joints at a maximum of 12 ft. (3.6 m) with no joints within 18 inches (450 mm) of corners or intersections unless otherwise indicated on Drawings.
 - 2. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures.
- D. Fastener Sizes: Use fasteners of sizes that penetrate substrate not less than recommended in writing by fastener manufacturer to achieve maximum pull-out resistance.
- E. Seal concealed joints with butyl sealant as required by roof specialty manufacturer.
- F. Seal joints as required for weathertight construction. Place sealant to be completely concealed in joint. Do not install sealants at temperatures below 40 deg F (4 deg C).

3.3 INSTALLATION OF ROOF-EDGE SPECIALTIES

- A. Install cleats, cants, and other anchoring and attachment accessories and devices with concealed fasteners.
- B. Anchor roof edgings with manufacturer's required devices, fasteners, and fastener spacing to meet performance requirements.

3.4 CLEANING AND PROTECTION

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing in accordance with ASTM A780/A780M.
- B. Touch up factory-primed surfaces with compatible primer ready for field painting in accordance with Section 099113 "Exterior Painting."
- C. Clean and neutralize flux materials. Clean off excess solder and sealants.
- D. Remove temporary protective coverings and strippable films as roof specialties are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain roof specialties in a clean condition during construction.
- E. Replace roof specialties that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures, as determined by Architect.

END OF SECTION 077100

SECTION 078413 - PENETRATION FIRESTOPPING

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. Penetrations in fire-resistance-rated walls.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: For each penetration firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing and inspecting agency.
 - 1. Engineering Judgments: Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping system, submit illustration, with modifications marked, approved by penetration firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly. Obtain approval of authorities having jurisdiction prior to submittal.

1.4 INFORMATIONAL SUBMITTALS

- A. Product test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:

1. Perform penetration firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
2. Test per testing standards referenced in "Penetration Firestopping Systems" Article. Provide rated systems complying with the following requirements:
 - a. Penetration firestopping systems shall bear classification marking of a qualified testing agency.
 - 1) UL in its "Fire Resistance Directory."
 - 2) Intertek Group in its "Directory of Listed Building Products."
 - 3) FM Global in its "Building Materials Approval Guide."

2.2 PENETRATION FIRESTOPPING SYSTEMS

- A. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Fire Protection Products.
 - b. Grabber Construction Products.
 - c. Hilti, Inc.
- B. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
1. F-Rating: Not less than the fire-resistance rating of constructions penetrated.
- C. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, per ASTM E 84.
- D. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.
- B. General: Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.
- C. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.
 - 1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.
- D. Install fill materials by proven techniques to produce the following results:
 - 1. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
 - 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
 - 3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.2 IDENTIFICATION

- A. Penetration Identification: Identify each penetration firestopping system with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches of penetration firestopping system edge so labels are visible to anyone seeking to remove penetrating items or firestopping systems. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:
 - 1. The words "Warning - Penetration Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
 - 2. Contractor's name, address, and phone number.
 - 3. Designation of applicable testing and inspecting agency.
 - 4. Date of installation.
 - 5. Manufacturer's name.
 - 6. Installer's name.

3.3 FIELD QUALITY CONTROL

- A. Owner and Architect will conduct an above ceiling punchlist. In addition, Owner may engage a qualified testing agency to perform tests and inspections according to ASTM E 2174.
- B. Where deficiencies are found or penetration firestopping system is damaged or removed because of testing, repair or replace penetration firestopping system to comply with requirements.
- C. Proceed with enclosing penetration firestopping systems with other construction only after punchlist items are completed, inspection reports are issued, and installations comply with requirements.

END OF SECTION 078413

SECTION 079200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Silicone joint sealants.
 - 2. Butyl joint sealants.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Silicone joint sealants.
 - 2. Butyl joint sealants.
- B. Samples for Initial Selection: Manufacturer's standard color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.
- C. Samples for Verification: For each type and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
- D. Joint-Sealant Schedule: Include the following information:
 - 1. Joint-sealant application, joint location, and designation.
 - 2. Joint-sealant manufacturer and product name.
 - 3. Joint-sealant formulation.
 - 4. Joint-sealant color.

1.3 INFORMATIONAL SUBMITTALS

- A. Preconstruction Laboratory Test Reports: For each joint sealant and substrate material to be tested from sealant manufacturer, indicating the following:
 - 1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
 - 2. Interpretation of test results and written recommendations for primers and substrate preparation are needed for adhesion.
- B. Preconstruction Field-Adhesion-Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.

- C. Field Quality-Control Reports: For field-adhesion-test reports, for each sealant application tested.
- D. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Manufacturers' special warranties.
- B. Installer's special warranties.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Qualified in accordance with ASTM C1021 to conduct the testing indicated.

1.6 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
 - 2. When joint substrates are wet.
 - 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 - 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.7 WARRANTY

- A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain joint sealants from single manufacturer for each sealant type.

2.2 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.3 SILICONE JOINT SEALANTS

- A. Silicone, S, NS, 50, NT: Single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 50, Use NT.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pecora Corporation
 - b. Sika Corporation - Building Components
 - c. The Dow Chemical Company

2.4 BUTYL JOINT SEALANTS

- A. Butyl-Rubber-Based Joint Sealants: ASTM C1311.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pecora Corporation
 - b. Sika Corporation - Building Components

2.5 JOINT-SEALANT BACKING

- A. Sealant Backing Material, General: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C1330, Type C (closed-cell material with a surface skin), and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.6 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - 2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - a. Concrete.
 - b. Masonry.
 - 3. Remove laitance and form-release agents from concrete.
 - 4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:

- a. Metal.
 - b. Glass.
- B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants in accordance with requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - 3. Provide concave joint profile in accordance with Figure 8A in ASTM C1193

unless otherwise indicated.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
 - a. Extent of Testing: Test completed and cured sealant joints as follows:
 - 1) Perform one test for each 1000 ft. of joint length thereafter or one test per each floor per elevation.
 - b. Inspect tested joints and report on the following:
 - 1) Whether sealants filled joint cavities and are free of voids.
 - 2) Whether sealant dimensions and configurations comply with specified requirements.
 - 3) Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion complies with sealant manufacturer's field-adhesion hand-pull test criteria.
 - c. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant material, sealant configuration, and sealant dimensions.
 - d. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.
 - 2. Evaluation of Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.
- C. Prepare test and inspection reports.

3.5 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION 079200

SECTION 092900 - GYPSUM BOARD

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. Interior gypsum board.
 - 2. Tile backing panels.
- B. Related Requirements:
 - 1. Section 092216 "Non-Structural Metal Framing" for non-structural steel framing and suspension systems that support gypsum board panels.

1.3 ACTION SUBMITTALS

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

1.4 DELIVERY, STORAGE AND HANDLING

- A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.
- B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.
- C. Do not install panels that are wet, moisture damaged, and mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or blotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.

2.2 GYPSUM BOARD, GENERAL

- A. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.3 INTERIOR GYPSUM BOARD

- A. Gypsum Board, Type X: ASTM C 1396/C 1396M.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Georgia-Pacific Building Products.
 - b. National Gypsum Company.
 - c. United States Gypsum Company.
 - 2. Thickness: 5/8 inch (15.9 mm).
 - 3. Long Edges: Tapered.
- B. Mold-Resistant Gypsum Board: ASTM C 1396/C 1396M. With moisture- and mold-resistant core and paper surfaces.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Georgia-Pacific Building Products.
 - b. National Gypsum Company.
 - c. United States Gypsum Company.
 - 2. Core: 5/8 inch (15.9 mm), Type X.
 - 3. Long Edges: Tapered.
 - 4. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.4 TILE BACKING PANELS

- A. Cementitious Backer Units: ANSI A118.9 and ASTM C 1288 or ASTM C 1325, with manufacturer's standard edges.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. James Hardie Building Products, Inc.
 - b. National Gypsum Company.
 - c. United States Gypsum Company.
2. Thickness: 5/8 inch (15.9 mm).
3. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.5 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.
2. Shapes:
 - a. Cornerbead.
 - b. LC-Bead: J-shaped; exposed long flange receives joint compound.
 - c. L-Bead: L-shaped; exposed long flange receives joint compound.
 - d. U-Bead: J-shaped; exposed short flange does not receive joint compound.
 - e. Expansion (control) joint.

B. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Fry Reglet Corporation.
2. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B 221 (ASTM B 221M), Alloy 6063-T5.
3. Finish: Satin nickel.

2.6 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:

1. Interior Gypsum Board: Paper.
2. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.

- a. Use setting-type compound for installing paper-faced metal trim accessories.
- 3. Fill Coat: For second coat, use setting-type, sandable topping compound.
- 4. Finish Coat: For third coat, use setting-type, sandable topping compound.
- D. Joint Compound for Tile Backing Panels:
 - 1. Cementitious Backer Units: As recommended by backer unit manufacturer.

2.7 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.
- B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.
- C. Steel Drill Screws: ASTM C 1002 unless otherwise indicated.
 - 1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.
 - 2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
- D. Sound-Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
 - 1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
- E. Acoustical Sealant: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.
- F. Thermal Insulation: As specified in Section 072100 "Thermal Insulation."
- G. Vapor Retarder: As specified in Section 072600 "Vapor Retarders."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

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

3.2 APPLYING AND FINISHING PANELS, GENERAL

- A. Comply with ASTM C 840.
- B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.
- D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- E. Form control and expansion joints with space between edges of adjoining gypsum panels.
- F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
 - 1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.
 - 2. Fit gypsum panels around ducts, pipes, and conduits.
 - 3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.
- G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
- I. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 APPLYING INTERIOR GYPSUM BOARD

- A. Install interior gypsum board in the following locations:
 - 1. Type X: Vertical surfaces unless otherwise indicated.
 - 2. Ceiling Type: Ceiling surfaces.
 - 3. Mold-Resistant Type: Men 112, Break room 113 wet walls, Decon 115, Mech 116, Women 120, and all wet locations.

- B. Single-Layer Application:
 - 1. On partitions/walls, apply gypsum panels vertically (parallel to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
 - a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
 - b. At high walls, install panels horizontally unless otherwise indicated or required by fire-resistance-rated assembly.
 - 2. Fastening Methods: Apply gypsum panels to supports with steel drill screws.
- C. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written instructions and temporarily brace or fasten gypsum panels until fastening adhesive has set.

3.4 APPLYING TILE BACKING PANELS

- A. Cementitious Backer Units: ANSI A108.11, at locations indicated to receive tile.
- B. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.5 INSTALLING TRIM ACCESSORIES

- A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
- B. Control Joints: Install control joints according to ASTM C 840 and in specific locations approved by Architect for visual effect.
- C. Interior Trim: Install in the following locations:
 - 1. Cornerbead: Use at outside corners.
 - 2. LC-Bead: Use at exposed panel edges.
- D. Aluminum Trim: Install in locations indicated on Drawings.

3.6 FINISHING GYPSUM BOARD

- A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
- B. Prefill open joints and damaged surface areas.
- C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

- D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:
 - 1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
 - 2. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
 - a. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."
- E. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.7 PROTECTION

- A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
- B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- C. Remove and replace panels that are wet, moisture damaged, and mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 092900

SECTION 093013 - CERAMIC TILING

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. Ceramic mosaic tile.
 - 2. Porcelain tile.
 - 3. Stone thresholds.
 - 4. Crack isolation membrane.
- B. Related Requirements:
 - 1. Section 079200 "Joint Sealants" for sealing of expansion, contraction, control, and isolation joints in tile surfaces.
 - 2. Section 092900 "Gypsum Board" for cementitious backer units.

1.3 DEFINITIONS

- A. General: Definitions in the ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.
- B. ANSI A108 Series: ANSI A108.01, ANSI A108.02, ANSI A108.1A, ANSI A108.1B, ANSI A108.1C, ANSI A108.4, ANSI A108.5, ANSI A108.6, ANSI A108.8, ANSI A108.9, ANSI A108.10, ANSI A108.11, ANSI A108.12, ANSI A108.13, ANSI A108.14, ANSI A108.15, ANSI A108.16, and ANSI A108.17, which are contained in its "Specifications for Installation of Ceramic Tile."
- C. Module Size: Actual tile size plus joint width indicated.
- D. Face Size: Actual tile size, excluding spacer lugs.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples for Initial Selection: For grout and accessories involving color selection.
- C. Samples for Verification:

1. Full-size units of each type and composition of tile and for each color and finish required.
2. Full-size units of each type of trim and accessory.
3. Stone thresholds in 6-inch (150-mm) lengths.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Certificates: For each type of product.
- C. Product Test Reports: For tile-setting and -grouting products.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.
 2. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installer is a Trowel of Excellence member of the Tile Contractors' Association of America.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.
- B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.
- D. Store liquid materials in unopened containers and protected from freezing.

1.9 FIELD CONDITIONS

- A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from single manufacturer and each aggregate from single source or producer.
 - 1. Obtain setting and grouting materials, except for unmodified Portland cement and aggregate, from single manufacturer.
- B. Source Limitations for Other Products: Obtain each of the following products specified in this Section from a single manufacturer:
 - 1. Stone thresholds.
 - 2. Crack isolation membrane.

2.2 PRODUCTS, GENERAL

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
 - 1. Provide tile complying with Standard grade requirements.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.
- C. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

2.3 TILE PRODUCTS

- A. Ceramic Tile: Floor and wall tile of types and sizes as indicated on Contract Drawings.

2.4 THRESHOLDS

- A. General: Fabricate to sizes and profiles indicated or required to provide transition between adjacent floor finishes.

1. Bevel edges at 1:2 slope, with lower edge of bevel aligned with or up to 1/16 inch (1.5 mm) above adjacent floor surface. Finish bevel to match top surface of threshold. Limit height of threshold to 1/2 inch (12.7 mm) or less above adjacent floor surface.
- B. Slate Thresholds: ASTM C 629/C 629M, Classification II Interior, with fine, even grain and honed finish.
 1. Description: Uniform, gray stone and unfading.

2.5 CRACK ISOLATION MEMBRANE

- A. General: Manufacturer's standard product that complies with ANSI A118.12 for standard performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.
- B. Corrugated Polyethylene: Corrugated polyethylene with dovetail-shaped corrugations and with anchoring webbing on the underside; 3/16-inch (4-mm) nominal thickness.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Schluter Systems L.P.; DITRA.

2.6 SETTING MATERIALS

- A. Latex-Portland Cement Mortar (Thin Set): ANSI A118.4.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Bonsal American; an Oldcastle company.
 - b. Bostik, Inc.
 - c. C-Cure.
 - d. Laticrete International, Inc.
 - e. MAPEI Corporation.
 - f. TEC; a subsidiary of H. B. Fuller Company.
 2. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
 3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.4.

2.7 GROUT MATERIALS

- A. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.
- B. Water-Cleanable Epoxy Grout: ANSI A118.3.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Bonsal American; an Oldcastle company.
 - b. Bostik, Inc.
 - c. C-Cure.
 - d. Laticrete International, Inc.
 - e. MAPEI Corporation.
 - f. TEC; a subsidiary of H. B. Fuller Company.
2. Provide product capable of withstanding continuous and intermittent exposure to temperatures of up to 140 deg F (60 deg C) and 212 deg F (100 deg C), respectively, and certified by manufacturer for intended use.

2.8 MISCELLANEOUS MATERIALS

- A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.
- B. Vapor-Retarder Membrane: Polyethylene sheeting, ASTM D 4397, 4.0 mils (0.1 mm) thick.
- C. Metal Accent Strips: Metal trim by Schluter or profile indicated on Contract Drawings.
- D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.
- E. Floor Sealer: Manufacturer's standard product for sealing grout joints and that does not change color or appearance of grout.

2.9 MIXING MORTARS AND GROUT

- A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
- B. Add materials, water, and additives in accurate proportions.
- C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
 - 2. Verify that concrete substrates for tile floors installed with thinset mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
 - a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
 - b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.
 - 3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.
 - 4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with thinset mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.
- B. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

3.3 CERAMIC TILE INSTALLATION

- A. Comply with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 series "Specifications for Installation of Ceramic Tile" that are referenced in TCNA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.
 - 1. For the following installations, follow procedures in the ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:

- a. Tile floors consisting of tiles 8 by 8 inches (200 by 200 mm) or larger.
- B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
- C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- D. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.
- E. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.
- F. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.
 - 1. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.
 - 2. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.
- G. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:
 - 1. Ceramic Mosaic Tile: 1/16 inch (1.6 mm).
 - 2. Porcelain Tile: 1/4 inch (6.4 mm).
- H. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.
- I. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.
 - 1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
- J. Stone Thresholds: Install stone thresholds in same type of setting bed as adjacent floor unless otherwise indicated.
 - 1. At locations where mortar bed (thickset) would otherwise be exposed above adjacent floor finishes, set thresholds in modified dry-set mortar (thinset).
 - 2. Do not extend crack isolation membrane under thresholds set in modified dry-set mortar. Fill joints between such thresholds and adjoining tile set on crack isolation membrane with elastomeric sealant.
- K. Floor Sealer: Apply floor sealer to cementitious grout joints in tile floors according to floor-sealer manufacturer's written instructions. As soon as floor sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.

3.4 CRACK ISOLATION MEMBRANE INSTALLATION

- A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.
- B. Allow crack isolation membrane to cure before installing tile or setting materials over it.

3.5 ADJUSTING AND CLEANING

- A. Remove and replace tile that is damaged or that does not match adjoining tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.
- B. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.
 - 1. Remove grout residue from tile as soon as possible.
 - 2. Clean grout smears and haze from tile according to tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3.6 PROTECTION

- A. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.
- B. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
- C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.7 INTERIOR CERAMIC TILE INSTALLATION SCHEDULE

- A. Interior Floor Installations, Concrete Subfloor:
 - 1. Tile Installation F125A: Thin-set mortar on crack isolation membrane; TCA F125A.
 - a. Thin-Set Mortar: Latex- portland cement mortar.
 - b. Grout: Water-cleanable epoxy grout.
- B. Interior Wall Installations, Wood or Metal Studs or Furring:
 - 1. Ceramic Tile Installation: TCNA W244C or TCNA W244F; thinset mortar on cementitious backer units or fiber-cement backer board.
 - a. Thinset Mortar: Modified dry-set mortar.
 - b. Grout: Water-cleanable epoxy grout.

END OF SECTION 093013

SECTION 095113 - ACOUSTICAL PANEL CEILINGS

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:
 - 1. Acoustical panels and exposed or concealed suspension systems for ceilings.
- B. Related Sections include the following:
 - 1. Division 07 Section "Joint Sealants" for acoustical sealant installed at the perimeter of Acoustical Panel Ceilings.

1.3 DEFINITIONS

- A. CAC: Ceiling Attenuation Class.
- B. LR: Light Reflectance coefficient.
- C. NRC: Noise Reduction Coefficient.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. For sealants, provide documentation including printed statement of VOC content.
- B. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of size indicated below.
 - 1. Acoustical Panel: Set of 6-inch- (150-mm-) square Samples of each type, color, pattern, and texture.
 - 2. Exposed Suspension System Members, Moldings, and Trim: Set of 6-inch-(150-mm-) long Samples of each type, finish, and color.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For finishes to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Acoustical Ceiling Panels: Full-size panels equal to 2.0 percent of quantity installed.
 - 2. Suspension System Components: Quantity of each exposed component equal to 2.0 percent of quantity installed.

1.7 QUALITY ASSURANCE

- A. Acoustical Testing Agency Qualifications: An independent testing laboratory, or an NVLAP-accredited laboratory, with the experience and capability to conduct the testing indicated. NVLAP-accredited laboratories must document accreditation, based on a "Certificate of Accreditation" and a "Scope of Accreditation" listing the test methods specified.
- B. Source Limitations: Obtain each type of acoustical ceiling panel and supporting suspension system through one source from a single manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver acoustical panels, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
- B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.
- C. Handle acoustical panels, suspension-system components and accessories carefully to avoid chipping edges or damaging units in any way.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1.10 COORDINATION

- A. Coordinate layout and installation of acoustical panels and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: Provide acoustical panel ceilings that comply with the following requirements:
 - 1. Surface-Burning Characteristics: Provide acoustical panels with the following surface-burning characteristics complying with ASTM E 1264 for Class A materials as determined by testing identical products per ASTM E 84:
 - a. Smoke-Developed Index: 50 or less.

2.2 ACOUSTICAL PANELS, GENERAL

- A. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances, unless otherwise indicated.
 - 1. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches (400 mm) away from test surface per ASTM E 795.
- B. Mineral-Fiber-Based Panels: Made with binder containing no urea formaldehyde.
- C. Acoustical Panel Colors and Patterns: Match appearance characteristics indicated for each product type, as indicated in the Finish Product List on the Drawings.

2.3 ACOUSTICAL PANELS FOR ACOUSTICAL PANEL CEILINGS

- A. Acoustical Panel **ACT-1**:
 - 1. Basis-of-Design Product: Armstrong; as indicated in the Material Specifications Schedule on the Drawings, or approved equal.
 - 2. Color: White.
 - 3. LR: Not less than 0.88.
 - 4. NRC: Not less than 0.75.
 - 5. CAC: Not less than 35.
 - 6. Edge/Joint Detail: Beveled tegular sized to fit flange of exposed suspension system members.
 - 7. Thickness: 3/4 inch.
 - 8. Modular Size: 24 by 24 inches (600 by 600 mm).

2.4 METAL SUSPENSION SYSTEMS, GENERAL

- A. Metal Suspension System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635/C 635M.
- B. Finishes and Colors, General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Provide manufacturer's standard factory-applied finish for type of system indicated.
- C. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
- D. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
 - 1. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
 - 2. Size: Select wire diameter so its stress at 3 times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) diameter wire.
- E. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.

2.5 METAL SUSPENSION SYSTEM FOR ACOUSTICAL PANEL CEILINGS

- A. Suspension System for Ceiling **ACT-1**: Subject to compliance with requirements, provide the following:
 - 1. Basis-of-Design Product: Armstrong; Prelude:
 - a. Structural Classification: Intermediate-duty system.
 - b. End Condition of Cross Runners: Override (stepped) or butt-edge type, as standard with manufacturer.
 - c. Flange Width: 15/16 inches (15mm).
 - d. Face Design: Flat, flush.
 - e. Cap Material: Cold-rolled steel or aluminum sheet.
 - f. Cap Finish: Painted white.

2.6 METAL EDGE MOLDINGS AND TRIM

- A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension system runners.
 - 1. Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners, unless otherwise indicated.

2. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.
3. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

2.7 ACOUSTICAL SEALANT

- A. Products: As specified in Division 07 Section "Joint Sealants".

2.8 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.
- B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

3.3 INSTALLATION OF SUSPENDED ACOUSTICAL CEILINGS

- A. General: Install acoustical panel ceilings to comply with ASTM C 636/C 636M and seismic design requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook".

- B. Suspend ceiling hangers from building's structural members and as follows:

ACOUSTICAL PANEL CEILINGS

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
 2. Splay hangers only where required and to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
 5. Secure hanger brackets to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
 6. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 7. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 8. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers, unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 9. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
- C. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
 2. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
 3. Do not use exposed fasteners, including pop rivets, on moldings and trim.
- D. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- E. Install acoustical panels with undamaged edges and fit accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.
1. Arrange directionally patterned acoustical panels with pattern running in one direction parallel to long axis of space, or as required to comply with approved mockups.
 2. For reveal-edged panels on suspension system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
 3. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections: Testing and inspecting of completed installations of acoustical panel ceiling hangers and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.
 - 1. Extent of Each Test Area: When installation of ceiling suspension systems has reached 20 percent completion but no panels have been installed.
 - a. Within each test area, testing agency will select 1 of every 10 fasteners used to attach hangers to supporting structure and will test them for 200 lbf (890 N) of tension.
 - b. When testing discovers fasteners that do not comply with requirements, testing agency will test those fasteners not previously tested until 20 pass consecutively and then will resume initial testing frequency.
- C. Acoustical panel ceiling hangers and fasteners will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Remove and replace acoustical panel ceiling hangers and fasteners that do not pass tests and inspections and retest as specified above.
- F. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.5 CLEANING

- A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 095113

SECTION 096813 - TILE CARPETING

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 modular carpet tile.
- B. Related Requirements:
 - 1. Section 096513 "Resilient Base and Accessories" for resilient wall base and transition strips installed with carpet tile.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
 - 2. Include manufacturer's written installation recommendations for each type of substrate.
- B. Samples for Verification: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.
 - 1. Carpet Tile: Full-size Sample.
 - 2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch- (300-mm-) long Samples.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.
- B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:
 - 1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.

2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Carpet Tile: Full-size units equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd. (8.3 sq. m).

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Comply with CRI's "CRI Carpet Installation Standard."

1.8 FIELD CONDITIONS

- A. Comply with CRI's "CRI Carpet Installation Standard" for temperature, humidity, and ventilation limitations.
- B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at levels planned for building occupants during the remainder of the construction period.
- C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.
- D. Where items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.9 WARRANTY

- A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.
 1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
 2. Failures include, but are not limited to, the following:
 - a. More than 10 percent edge raveling, snags, and runs.
 - b. Dimensional instability.
 - c. Excess static discharge.
 - d. Loss of tuft-bind strength.
 - e. Loss of face fiber.
 - f. Delamination.
 3. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARPET TILE (CPT-1, CPT-2 & CPT-3)

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings.
- B. Color: As indicated by manufacturer's designations.
- C. Installed Pattern: Quarter turn
- D. Size: 24 by 24 inches (610 by 610 mm).
- E. Applied Treatments:
 - 1. Soil-Resistance Treatment: Manufacturer's standard treatment.
 - 2. Antimicrobial Treatment: Manufacturer's standard treatment that protects carpet tiles as follows:
 - a. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria, not less than 1-mm halo of inhibition for gram-negative bacteria, and no fungal growth, according to AATCC 174.

2.2 INSTALLATION ACCESSORIES

- A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.
- B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that comply with flammability requirements for installed carpet tile, and are recommended by carpet tile manufacturer for releasable installation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance.
- B. Examine carpet tile for type, color, pattern, and potential defects.
- C. Concrete Slabs: Verify that finishes comply with requirements specified in Section 033000 "Cast-in-Place Concrete" and that surfaces are free of cracks, ridges, depressions, scale, and foreign deposits.

1. Moisture Testing: Perform tests so that each test area does not exceed 1000 sq. ft. (304.8 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
 - b. Relative Humidity Test: Using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
 - c. Perform additional moisture tests recommended in writing by adhesive and carpet tile manufacturers. Proceed with installation only after substrates pass testing.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Comply with CRI's "Carpet Installation Standards" and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile.
- B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch (3 mm) wide or wider, and protrusions more than 1/32 inch (0.8 mm) unless more stringent requirements are required by manufacturer's written instructions.
- C. Concrete Substrates: Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by adhesive and carpet tile manufacturers.
- D. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

- A. General: Comply with CRI's "CRI Carpet Installation Standard," Section 18, "Modular Carpet" and with carpet tile manufacturer's written installation instructions.
- B. Installation Method: Partial glue down; install periodic tiles with releasable, pressure-sensitive adhesive.
- C. Maintain dye-lot integrity. Do not mix dye lots in same area.
- D. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.
- E. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

- F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on carpet tile as marked on subfloor. Use nonpermanent, nonstaining marking device.
- G. Install pattern parallel to walls and borders.

3.4 CLEANING AND PROTECTION

- A. Perform the following operations immediately after installing carpet tile:
 - 1. Remove excess adhesive and other surface blemishes using cleaner recommended by carpet tile manufacturer.
 - 2. Remove yarns that protrude from carpet tile surface.
 - 3. Vacuum carpet tile using commercial machine with face-beater element.
- B. Protect installed carpet tile to comply with CRI's "Carpet Installation Standard," Section 20, "Protecting Indoor Installations."
- C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION 096813

SECTION 099113 - EXTERIOR PAINTING

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 surface preparation and the application of paint systems on exterior substrates.
- B. Related Requirements:
 - 1. Section 099123 "Interior Painting" for surface preparation and the application of paint systems on interior substrates.

1.3 DEFINITIONS

- A. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.
- B. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
- B. Samples for Initial Selection: For each type of topcoat product.
- C. Samples for Verification: For each type of paint system and each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
- D. Product List: For each product indicated, include the following:
 - 1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
 - 2. Printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Behr Process Corporation.
 - 2. Benjamin Moore & Co.
 - 3. Frazee Paint.
 - 4. ICI Paints.
 - 5. Kelly-Moore Paints.
 - 6. PPG Architectural Finishes, Inc.
 - 7. Pratt & Lambert.
 - 8. Sherwin-Williams Company (The).

2.2 PAINT, GENERAL

- A. MPI Standards: Provide products that comply with MPI standards indicated and that are listed in its "MPI Approved Products List."
- B. Material Compatibility:

1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.
- C. Colors: As selected by Architect from manufacturer's full range. Assume three colors for bidding purposes.

2.3 METAL PRIMERS

- A. Primer, Quick Dry, for Aluminum: MPI #95.

2.4 WATER-BASED PAINTS

- A. Latex, Exterior Semi-Gloss (Gloss Level 5): MPI #11.
- B. Light Industrial Coating, Exterior, Water Based (Gloss Level 3): MPI #161.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
- C. Proceed with coating application only after unsatisfactory conditions have been corrected.
1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates and paint systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer.
- E. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- F. Aluminum Substrates: Remove loose surface oxidation.

3.3 APPLICATION

- A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Manual."
1. Use applicators and techniques suited for paint and substrate indicated.
 2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
 3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- E. Painting Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
1. Paint the following work where exposed to view:
 - a. Metal conduit.

3.4 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.5 EXTERIOR PAINTING SCHEDULE

A. Steel Substrates:

- 1. Water-Based Light Industrial Coating System:
 - a. Intermediate Coat: Light industrial coating, exterior, water based, matching topcoat.
 - b. Topcoat: Light industrial coating, exterior, water based (Gloss Level 3), MPI #161.

B. Aluminum Substrates:

- 1. Latex System:
 - a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
 - b. Intermediate Coat: Latex, exterior, matching topcoat.
 - c. Topcoat: Latex, exterior semi-gloss (Gloss Level 5), MPI #11.

END OF SECTION 099113

SECTION 099123 - INTERIOR PAINTING

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 surface preparation and the application of paint systems on interior substrates.
- B. Related Requirements:
 - 1. Section 051200 "Structural Steel Framing" for shop priming of metal substrates with primers specified in this Section.
 - 2. Section 099113 "Exterior Painting" for surface preparation and the application of paint systems on exterior substrates.

1.3 DEFINITIONS

- A. Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.
- B. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
- B. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
- C. Product List: For each product indicated, include the following:
 - 1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
 - 2. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product by Sherwin Williams as indicated on Drawings or comparable product by one of the following:
 - 1. Behr Process Corporation.
 - 2. Benjamin Moore & Co.
 - 3. Glidden Professional.
 - 4. PPG Architectural Coatings.

2.2 PAINT, GENERAL

- A. MPI Standards: Provide products that comply with MPI standards indicated and that are listed in its "MPI Approved Products List."
- B. Material Compatibility:
 - 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

- C. Colors: As indicated by manufacturer's designations on Contract Drawings.

2.3 PRIMERS/SEALERS

- A. Primer Sealer, Latex, Interior: MPI #50.
- B. Primer Sealer, Interior, Institutional Low Odor/VOC: MPI #149.

2.4 METAL PRIMERS

- A. Primer, Rust-Inhibitive, Water Based: MPI #107.
- B. Primer, Alkyd, Quick Dry, for Metal: MPI #76.
- C. Primer, Quick Dry, for Aluminum: MPI #95.

2.5 WATER-BASED PAINTS

- A. Latex, Interior, Institutional Low Odor/VOC, (Gloss Level 2): MPI #144.
- B. Latex, Interior, Institutional Low Odor/VOC, (Gloss Level 3): MPI #145.

2.6 DRY FOG/FALL COATINGS

- A. Dry Fall, Latex, Flat: MPI #118.
- B. Dry Fall, Water Based, for Galvanized Steel, Flat (Gloss Level 1): MPI #133.

2.7 ALUMINUM PAINT

- A. Aluminum Paint: MPI #1.

2.8 FLOOR COATINGS

- A. Stain, Interior, for Concrete Floors: MPI #58.
- B. Sealer, Water Based, for Concrete Floors: MPI #99.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - 1. Concrete: 12 percent.
 - 2. Gypsum Board: 12 percent.
- C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
- E. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.
- E. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
 - 1. SSPC-SP 2, "Hand Tool Cleaning."
- F. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- G. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal fabricated from coil stock by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.
- H. Aluminum Substrates: Remove loose surface oxidation.

- I. Cotton or Canvas Insulation Covering Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.3 APPLICATION

- A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
 1. Use applicators and techniques suited for paint and substrate indicated.
 2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- E. Painting Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
 1. Paint the following work where exposed in occupied spaces:
 - a. Equipment, including panelboards.
 - b. Uninsulated metal piping.
 - c. Uninsulated plastic piping.
 - d. Pipe hangers and supports.
 - e. Metal conduit.
 - f. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
 - g. Other items as directed by Architect.
 2. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.5 INTERIOR PAINTING SCHEDULE

- A. Concrete Substrates, Traffic Surfaces:
 - 1. Concrete Stain System:
 - a. First Coat: Stain, interior, for concrete floors, MPI #58.
 - b. Topcoat: Stain, interior, for concrete floors, MPI #58.
 - 2. Water-Based Clear Sealer System:
 - a. Topcoat: Sealer, water based, for concrete floors, MPI #99.
- B. Steel Substrates:
 - 1. Water-Based Dry-Fall System:
 - a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79.
 - b. Topcoat: Dry fall, latex, flat, MPI #118.
 - 2. Institutional Low-Odor/VOC Latex System:
 - a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79.
 - b. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
- C. Galvanized-Metal Substrates:
 - 1. Water-Based Dry-Fall System:
 - a. Topcoat: Dry fall, water based, for galvanized steel, flat (Gloss Level 1), MPI #133.
 - 2. Institutional Low-Odor/VOC Latex System:
 - a. Prime Coat: Primer, alkyd, anti-corrosive, for metal, MPI #79.
 - b. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
- D. Aluminum (Not Anodized or Otherwise Coated) Substrates:

1. Aluminum Paint System:
 - a. Prime Coat: Primer, vinyl wash, MPI #80.
 - b. Topcoat: Aluminum paint, MPI #1.
- E. Fiberglass and Plastic Substrates:
 1. Institutional Low-Odor/VOC Latex System:
 - a. Prime Coat: Primer, bonding, water based, MPI #17.
 - b. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.
- F. Gypsum Board Substrates:
 1. Institutional Low-Odor/VOC Latex System:
 - a. Prime Coat: Primer sealer, interior, institutional low odor/VOC, MPI #149.
 - b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
 - c. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 3), MPI #145.
- G. Cotton or Canvas and ASJ Insulation-Covering Substrates: Including pipe and duct coverings.
 1. Institutional Low-Odor/VOC Latex System:
 - a. Prime Coat: Primer sealer, latex, interior, MPI #50.
 - b. Topcoat: Latex, interior, institutional low odor/VOC, (Gloss Level 2), MPI #144.

END OF SECTION 099123

SECTION 101423 - PANEL SIGNAGE

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 panel signs that are directly attached to the building:
 - 1. Room Identification Sign Type.
 - 2. Room Identification with Pictogram (i.e. Men, Women) Sign Type.

1.3 DEFINITIONS

- A. Accessible: In accordance with the accessibility standard.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For panel signs.
 - 1. Include fabrication and installation details and attachments to other work.
 - 2. Show sign mounting heights, locations of supplementary supports to be provided by other installers, and accessories.
 - 3. Show message list, typestyles, graphic elements, including raised characters and Braille, and layout for each sign at least half size.
- C. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:
 - 1. Room-Identification Signs: Full-size Sample.
 - 2. Variable Component Materials: Full-size Sample of each base material, character (letter, number, and graphic element) in each exposed color and finish not included in Samples above.
 - 3. Full-size Samples, if approved, will be returned to Contractor for use in Project.
- D. Product Schedule: For panel signs. Use same designations indicated on Drawings or specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and manufacturer.

- B. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For signs to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Deterioration of finishes beyond normal weathering.
 - b. Deterioration of embedded graphic image.
 - c. Separation or delamination of sheet materials and components.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1.

2.2 PANEL SIGNS

- A. Panel Sign Types as shown in the Construction Documents: Sign with smooth, uniform surfaces; with message and characters having uniform faces, sharp corners, and precisely formed lines and profiles; and as follows:
 1. Product: as shown in the Construction Documents. Subject to compliance with requirements, provide the named product.
 1. Solid-Sheet Sign, Returns, and Back: As specified on Drawings or by ASI product type with finish specified in "Surface Finish and Applied Graphics" Subparagraph and as follows:
 - a. Thickness: Manufacturer's standard for size of sign
 - a. Surface-Applied, Flat Graphics: Applied vinyl film.
 - b. Surface-Applied, Raised Graphics: Applied polymer characters and Braille Insert ADA requirement.

- c. Color(s): As selected by Architect from full range of industry colors.
- 2. Sign-Panel Perimeter: Finish edges smooth.
 - a. Edge Condition: Square cut.
 - b. Corner Condition in Elevation: Square.
- 3. Mounting: Manufacturer's standard method for substrates indicated with adhesive two-face tape.
 - a. At signs mounted on clear glass where the rear of the sign is visible from inside the room, provide a back painted panel, equal in size to the sign, on the room side of the sign so that the adhesive two-face tape is not visible.
- 4. Text and Typeface: Accessible raised characters and Braille typeface as indicated on Drawings. Finish raised characters to contrast with background color, and finish Braille to match background color.
- 5. Flatness Tolerance: Sign shall remain flat or uniformly curved under installed conditions as indicated on Drawings and within a tolerance of plus or minus 1/16 inch (1.5 mm)] measured diagonally from corner to corner.

2.3 SIGN MATERIALS

- A. Acrylic Sheet: ASTM D 4802, category as standard with manufacturer for each sign, Type UVF (UV filtering).
- B. Paints and Coatings for Sheet Materials: Inks, dyes, and paints that are recommended by manufacturer for optimum adherence to surface and are UV and water resistant for colors and exposure indicated.

2.4 ACCESSORIES

- A. Two-Face Tape: Manufacturer's standard high-bond, foam-core tape, 0.045 inch (1.14 mm) thick, with adhesive on both sides.

2.5 FABRICATION

- A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
 - 1. Preassemble signs and assemblies in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
 - 2. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.
 - 3. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
 - 4. Provide rabbets, lugs, and tabs necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.

- B. Surface-Applied Graphics: Apply graphics to face of clear face-sheet material to produce precisely formed image. Image shall be free of rough edges.
- C. Signs with Changeable Message Capability: Fabricate signs to allow insertion of changeable messages.

2.6 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
 - 1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.
 - 2. Install signs so they do not protrude or obstruct according to the accessibility standard.
 - 3. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.
- B. Accessibility: Install signs in locations on walls as indicated on Drawings and according to the accessibility standard.
- C. Mounting Methods:
 - 1. Two-Face Tape: Clean bond-breaking materials from substrate surface and remove loose debris. Apply tape strips symmetrically to back of sign and of suitable quantity to support weight of sign without slippage. Keep strips away from edges to prevent visibility at sign edges. Place sign in position, and push to engage tape adhesive.

3.2 ADJUSTING AND CLEANING

- A. Remove and replace damaged or deformed signs and signs that do not comply with specified requirements. Replace signs with damaged or deteriorated finishes or components that cannot be successfully repaired by finish touchup or similar minor repair procedures.
- B. Remove temporary protective coverings and strippable films as signs are installed.

- C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by Owner.

END OF SECTION 101423

SECTION 102800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Washroom accessories.

1.2 COORDINATION

- ##### A.
- Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.

1.3 ACTION SUBMITTALS

- ##### A.
- Product Data: For each type of product.

- ##### B.
- Samples: For each exposed product and for each finish specified, full size.

1. Approved full-size Samples will be returned and may be used in the Work.

1.4 INFORMATIONAL SUBMITTALS

- ##### A.
- Sample Warranty: For manufacturer's special warranties.

1.5 CLOSEOUT SUBMITTALS

- ##### A.
- Maintenance Data: For accessories to include in maintenance manuals.

1.6 WARRANTY

- ##### A.
- Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- 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. Structural Performance: Design accessories and fasteners to comply with the following requirements:
 - 1. Grab Bars: Installed units are able to resist 250 lbf concentrated load applied in any direction and at any point.

2.2 WASHROOM ACCESSORIES

- A. Mirror Unit :
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Bobrick; B-165 or equal.
 - 2. Frame: Stainless steel channel.
 - a. Corners: Manufacturer's standard.
 - 3. Size: As indicated on Drawings.

2.3 UNDERLAVATORY GUARDS

- A. Underlavatory Guard:
 - 1. Description: Insulating pipe covering for supply and drain piping assemblies that prevents direct contact with and burns from piping; allow service access without removing coverings.
 - 2. Material and Finish: Antimicrobial, molded plastic, white.

2.4 MATERIALS

- A. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.031-inch-minimum nominal thickness unless otherwise indicated.
- B. Steel Sheet: ASTM A1008/A1008M, Designation CS (cold rolled, commercial steel), 0.036-inch-minimum nominal thickness.

- C. Galvanized-Steel Mounting Devices: ASTM A153/A153M, hot-dip galvanized after fabrication.
- D. Fasteners: Screws, bolts, and other devices of same material as accessory unit, unless otherwise recommended by manufacturer or specified in this Section, and tamper and theft resistant where exposed, and of stainless or galvanized steel where concealed.
- E. Chrome Plating: ASTM B456, Service Condition Number SC 2 (moderate service).
- F. Mirrors: ASTM C1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.5 FABRICATION

- A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.
- B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install accessories in accordance with manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
 - 1. Remove temporary labels and protective coatings.
- B. Grab Bars: Install to comply with specified structural-performance requirements.
- C. Shower Seats: Install to comply with specified structural-performance requirements.

3.2 ADJUSTING AND CLEANING

- A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.
- B. Clean and polish exposed surfaces in accordance with manufacturer's written instructions.

END OF SECTION 102800

SECTION 122412 – TRANSPARENT PLASTIC WINDOW SHADES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manually operated, single-roller shades for use in Airport Traffic Control Tower (ATCT) cabs.

B. Referenced Standards:

1. The current issues of the publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only:
 - a. FEDERAL SPECIFICATION (FS)
 - 1) FS L-P-377 - Plastic Sheet and Strip Polyester
 - b. ASSOCIATION OF INDUSTRIAL METALIZERS, COATERS AND LAMINATORS (AIMCAL)
 - 1) AIMCAL - Standard Methods
 - c. FEDERAL STANDARD (FED-STD)
 - 1) FED-STD-102 - Preservation, Packaging, and Packing Level

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, features, finishes, and operating instructions for roller shades.

B. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations.

C. Samples: For each exposed product and for each color and texture specified, 10 inches (250 mm) long.

D. Product Schedule: For roller shades.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

- B. Product Certificates: For each type of shadeband material.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For roller shades to include in maintenance manuals.

1.5 WARRANTY

- A. Manufacturer agrees to repair or replace components of that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year from date of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver roller shades in factory packages, meeting FED-STD-102, marked with manufacturer, product name, and location of installation using same designations indicated on Drawings.
- B. Store in a safe, dry, clean, and well-ventilated area with temperature maintained above 60 degrees F for two (2) days prior to installation. Do not open containers until needed for installation unless verification inspection is required.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Do not install roller shades until construction and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
- B. Field Measurements: Where roller shades are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Architect of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain roller shades from single source from single manufacturer.

2.2 MANUALLY OPERATED, SINGLE-ROLLER SHADES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Plastic-View ATC; F72 SR or Architect approved equal.

B. Transparent Plastic Shade Material

1. Material: Shade material shall be manufactured from a polyester type polymer in accordance with Federal Specification L-F-377b for type weatherable DuPont Mylar clear sheet film or other manufacturer approved by the COTR. Fire resistant rated "self-extinguishing to very slow burning" U.S. Testing Company, fire test 302; melting point 500 deg. F, combustion 977 deg. F. no toxic hazard.
2. Construction: Shade product shall consist of a 5 mil, 3-ply laminated polyester film. Two sheets of polyester vat dyed gray, hard coat S/R applied to one side. The final film construction shall be 5 gauge thick, optically clear and totally transparent. Surface tinting or color adhesives will not be acceptable.
3. Visible Light Transmission: Shade shall transmit no more than 4 percent of the visible solar energy (from 380 to 780 nanometers) when measured by Association of Industrial Metalizers, Coaters, and Laminators (AIMCAL) Standard Methods or ASTM E-903-96 test procedures.
4. Ultra-Violet Transmission: No more than 1 percent of the ultra-violet solar energy (from 800 to 780 nanometers) when measured by AIMCAL Standard Methods.
5. Emissivity: Not higher than 0.80
6. Visible Light Reflectance: Not more than 6 percent when measured in accordance with ASTM E-903-96.
7. Shading Coefficient: Not more than 0.40.
8. Total Solar Energy Rejected: Shade will reject 60 percent of the total solar energy transmitted when measured by ASTM E903-96.
9. Solar Absorption: Not less than 60 percent (\pm 2 percent).
10. Solar Heat Gain Coefficient: Not less than 0.40.

C. Bottom Bar: Shades shall have a flat 1-inch by 1/2 inch, dull black, full width metal hemline bar, minimum of 26 gage, at bottom onto which the pull cord and shade are attached. Black plastic caps shall be provided on each end of hemline bar to cover any sharp exposed edges.

D. Shade Cords: Shade cords shall be black and of sufficient length to route around equipment to cord lock positions whenever required. The cords shall be nominal 3/16 inch diameter rope made of Duro Nylon and shall be attached underneath the center of the bottom of the hemline bar.

E. Mounting Brackets: Provide mounting brackets with a 2-1/4 inch resting ledge and 1-1/2 inch high slots. Standard ceiling brackets are not acceptable. Bracket accepting plug end is to have elongated screw holes to allow for slight position adjustments. Roll-off direction of material from roller shall be as directed by the shade manufacturer for use in the tower cab.

F. Shade Rollers: Shades shall be mounted on a 1-3/4 inch diameter corrosion resistant metal wrapped roller. The rollers shall be spring loaded, single piece barrel, with a reusable safety cotter key type retainer installed through both end pins and washers to prevent roller from falling out of mounting brackets. Roller spring to be of length required to ensure smooth, consistent, comfortable operation. Constant tensions in shades is required.

G. Each shade shall have a label or whatever suit able means required to specify and identify the proper roll-off direction.

H. Each shade shall have a manufacturer's label attached to the metal bar hemline giving cleaning instructions and the telephone number for emergency service.

- I. Lock Pulley: Lock pulleys shall consist of a roller and a spring return side action cam cord grip. Cord direction change pulley shall be used to route shade cord around obstructions where they exist. Pulleys shall be positioned in a direct line with the cord outlet on the metal hemline.
- J. Shade Size: Shade roller width shall be within 1/2-inch of maximum possible width as determined by physical limitations. Shade material with shade fully drawn shall be to within 1 inch of columns on bias cut sides and to within 1-3/4 inch of columns on vertical cut sides. Horizontal seam shall be located a minimum of 70 inches from the bottom of the shade. Shades in ATCT cabs shall be bias cut when required. To ensure a safe roll-up, a minimum of 15 inches of shade material shall remain on the roller when the shade is fully extended.
- K. Measuring for Shades: Measuring for shades and positioning shall be strictly in accordance with the shade manufacturer's instructions. Marks showing the precise position of all brackets, pulleys, and metal hemline positions as related to the factory measuring instructions shall be provided. All measurements shall be taken per instructions from shade manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ROLLER SHADE INSTALLATION

- A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.
- B. Shades shall follow the slope of cab glass as closely as practical within physical limitations of air ducts and other equipment. No drilling shall be done in vertical uprights of cab.
- C. Roller Shade Locations: Ceiling mounted within window framework on all windows in the tower Cab, as indicated on Drawings. Carefully field verify all finished openings for exact sizing of shades.
- D. In order to safely control and limit the shade travel, the installer shall make two knots in the shade cord. One knot shall be placed before the lock pulley to prevent the metal hemline bar from hitting the windowsill. The second knot shall be placed after the lock pulley to prevent the metal hemline bar from hitting and overrunning the shade roller.
- E. Adherence to the "This End Down" label when installing the shade will prevent improper roller installation which can result in a locked shade situation when the metal hemline bar is near the lock pulley and cannot be pulled down to release the spring motor cam lock.

3.3 ADJUSTING

- A. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.
- B. Spring tension in roller shall be manually adjusted so that shades roll comfortably and do not bind.
- C. Adjust the uppermost and lowermost limits.

3.4 CLEANING AND PROTECTION

- A. Clean roller shade surfaces, after installation, according to manufacturer's written instructions.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that roller shades are without damage or deterioration at time of Substantial Completion.
- C. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

END OF SECTION 122412

SECTION 123661 - SIMULATED STONE COUNTERTOPS

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. Solid-surface-material for stools, countertops, and backsplashes.
- B. Related Sections:
 - 1. Section 224000 "Plumbing Fixtures" for non integral sinks and plumbing fittings.

1.3 ACTION SUBMITTALS

- A. Product Data: For countertop materials.
- B. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.
- C. Samples for Verification: For each type of material exposed to view.

1.4 PROJECT CONDITIONS

- A. Field Measurements: Verify dimensions of countertops by field measurements after base cabinets are installed but before countertop fabrication is complete.

1.5 COORDINATION

- A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.1 SOLID-SURFACE-MATERIAL COUNTERTOPS

- A. Configuration: Provide countertops with the following front and backsplash style:
 - 1. Front: Radius edge with apron, 2 inches high with 3/8-inch radius.

- 2. Backsplash: Radius edge with 3/8-inch radius.
- B. Countertops: 1/2-inch- thick, solid surface material with front edge built up with same material.
- C. Backsplashes: 1/2-inch- thick, solid surface material.
- D. Fabrication: Fabricate tops in one piece with shop-applied edges and backsplashes unless otherwise indicated. Provide field installed 2 layers 1/2" plywood underlayment beneath all countertops. Comply with solid-surface-material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.

2.2 COUNTERTOP MATERIALS

- A. Solid Surface Material: Homogeneous solid sheets of filled plastic resin complying with ANSI SS1.
- A. Basis-of-Design Product: Subject to compliance with requirements, provide materials by Corian, or Architect's approved equal.
 - 1. Colors and Patterns: As indicated on the Contract Drawings.

2.3 COUNTERTOP SUPPORT BRACKETS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Rakks EH1824 or approved equal.
 - 1. Size: 18"x24"
 - 2. Material and Finish: Aluminum with mill finish.

2.4 COUNTERTOP EDGE SUPPORTS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Rakks EH-CS or approved equal.
 - 1. Size: Length to match countertop support brackets.
 - 2. Material and Finish: Finish to match countertop support brackets.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install countertops level to a tolerance of 1/8 inch in 8 feet.
- B. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Pre-drill holes for screws as recommended by manufacturer. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

END OF SECTION 123661

SECTION 220529 - SUPPORTS AND ANCHORS

PART 1 GENERAL

1.1 SCOPE

- A. Pipe and equipment hangers, supports, and associated anchors.
- B. Flashing and sealing.
- C. Sleeves and seals.
- D. Equipment curbs, bases and supports.
- E. Vibration isolators.

1.2 RELATED WORK

- A. Section 220700 – Piping Insulation
- B. Section 223000 – Plumbing – General
- C. Division 21 – Fire Protection
- D. Division 3 – Concrete
- E. Division 5 – Miscellaneous Metal Work: Steel Angle and Channel

1.3 REFERENCES

- A. ANSI Standards
- B. ASME Standards
- C. Building Code of New York State 2007– Piping Seismic Supports
- D. Plumbing Code of New York State 2007

1.4 QUALITY ASSURANCE

- A. In conformance with Structural Safety Requirements of the Building Code of New York State 2007.

1.5 SUBMITTALS

- A. Product Data: Manufacturer's descriptive literature indicating specifications, load capacity and construction for products furnished.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, Carbon steel, adjustable swivel, split ring.
- B. Hangers for all Pipe Sizes 2 to 3 Inches and Cold Pipe Sizes Over 3 inches: Carbon steel, adjustable, clevis.
- C. Hangers for Hot Pipe Sizes Over 3 Inches: Adjustable steel yoke, cast iron roll, double hanger.
- D. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods; cast iron roll and stand for hot pipe sizes 6 inches and over.
- E. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- F. Wall Support for Cold Pipe Sizes Over 3 Inches: Welded steel bracket and wrought steel clamp.
- G. Wall Support for Hot Pipe Sizes Over 3 Inches: Welded steel bracket, adjustable steel yoke and cast iron roll.
- H. Vertical Support: Steel riser clamp.
- I. Floor Support for Hot Pipe Sizes to 3 Inches and All Cold Pipe Sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- J. Floor Support for Hot Pipe Sizes Over 3 Inches: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- K. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- L. Shield for Insulated Piping 2 Inches and Smaller: 18 gage galvanized steel shield over insulation in 180 degree segments, minimum 12 inches long at pipe support.
- M. Shield for Insulated Piping 2-1/2 Inches and Larger (Except Cold Water Piping): Pipe covering protective saddles.
- N. Shields for Insulated Cold Water Piping 2-1/2 Inches and Larger: Hard block non-conducting saddles in 90 degree segments, 12 inch minimum length, block thickness same as insulation thickness.
- O. Shields for Vertical Copper Pipe Risers: Sheet lead.
- P. Manufacturer: Grinnell or equal.

2.2 MISCELLANEOUS HANGERS AND SUPPORTS

A. Beam Clamps.

1. Material: Malleable Iron.
2. Service: Recommended for use on American Standard I-beams and wide flange beams.
3. UL listed.
4. Manufacturer: Grinnell or equal.

2.3 HANGER RODS

A. Steel Hanger Rods: Cadmium plated, threaded both ends, threaded one end, or continuous threaded.

2.4 INSERTS AND FASTENERS

A. Concrete Inserts: Malleable iron body and nut of galvanized, black finish for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms. Manufacturer: CB - Universal or equal.

B. Concrete Fasteners: Steel shell and expander plug for threaded connection. Manufacturer: Phillips or equal.

C. Size inserts and fasteners to suit threaded hanger rods.

2.5 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Lead Flashing: 5 lb/sq ft sheet lead for waterproofing; one lb/sq ft sheet lead for soundproofing.

C. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.

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

2.6 EQUIPMENT CURBS, BASES AND SUPPORTS

A. Bases: Concrete - Refer to Division 3.

B. Supports: Steel channel and/or angle - Refer to Division 5.

- C. Equipment curbs shall be provided by the equipment manufacturer.

2.7 SLEEVES

- A. Sleeves for Pipes Through Non-fire Rated Floors: Form with 18 gage galvanized steel.
- B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with steel pipe or 18 gage galvanized steel.
- C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fireproofing: Prefabricated fire rated sleeves including seals, UL listed.
- D. Stuffing, Fire Stopping Insulation: Glass fiber type, non-combustible.
- E. Caulk: Acrylic sealant.
- F. Fire Resistant Joint Sealers: Two part, foamed in place, silicone sealant formulated for use in through penetration fire stopping around pipe penetrations through fire rated walls and floors.
- G. Sleeves shall be two sizes larger than the pipe passing through.

2.8 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers without disengagement of supported pipe.

2.9 FINISH

- A. Hangers and supports shall be galvanized steel unless otherwise specified.
- B. Prime coat exposed black steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

2.10 VIBRATION ISOLATORS

- A. Closed spring hangers or mounts with stiff springs (horizontal stiffness equal to vertical stiffness) in series with acoustic isolation pads.
- B. Hanger isolators shall be designed to accommodate rod misalignment over a 30° arc.
- C. Isolator sizing shall be based on equipment weight.
- D. Spring isolators shall be designed to provide 50% overload capacity.
- E. Hanger assembly including isolator bracket shall be designed to carry a 500% overload without

failure.

- F. Manufacturer: Kinetics or approved equal.

PART 3 EXECUTION

3.1 INSERTS AND FASTENERS

- A. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- B. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
- C. Provide inserts and fasteners for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.2 PIPE HANGERS AND SUPPORTS

- A. Support horizontal and vertical piping as follows and in accordance with the Plumbing Code of New York State.

<u>PIPE SIZE</u>	<u>MAX. HANGER SPACING</u>	<u>HANGER DIAMETER</u>
Less than 1 inch	5'-0"	3/8"
1 to 1-1/4 inch	6'-0"	3/8"
1-1/2 to 2 inch	9'-0"	3/8"
2-1/2 to 3 inch	10'-0"	1/2"
4 to 6 inch	10'-0"	5/8"
8 to 12 inch	14'-0"	7/8"
14 inch and Over	20'-0"	1"
PVC (All Sizes)	4'-0"	1/2"
C.I. Bell and Spigot (or No-Hub)	5'-0" and at Joints	Refer to Pipe Size

- B. Anchorage shall be provided to restrain drainage piping from axial movement. For pipe sizes greater than 4 inches, restraints shall be provided for drainpipes at all changes in diameter greater than two pipe sizes. Braces, blocks, rodding, and other suitable methods as specified by the coupling manufacturer shall be utilized.

- C. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
- D. Place a hanger within 12 inches of each horizontal elbow.
- E. Use hangers with 1-1/2 inch minimum vertical adjustment.
- F. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- G. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- I. Bases of stacks shall be supported by concrete, brick laid in cement mortar or metal brackets attached to the building.
- J. Support riser piping independently of connected horizontal piping.
- K. Rigid support sway bracing shall be provided at changes in direction greater than 45 degrees for pipe sizes 4 inches and larger.
- L. Provide rigid anchors for pipes at equipment after vibration isolation components are installed.

3.3 EQUIPMENT CURBS, BASES AND SUPPORTS

- A. Provide equipment bases of concrete type specified in Division 3.
- B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- C. Construct support of steel angle and/or channel, steel pipe and fittings. Brace and fasten with flanges bolted to structure.

3.4 FLASHING

- A. Provide flexible flashing and metal counterflashing where piping penetrates weather or waterproofed walls, floors and roofs.
- B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash and seal.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36-inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor drains, shower, mop sink drains watertight to adjacent materials.

- E. Provide acoustical lead flashing around pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.
- F. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface. Flexible sheet flash and counterflash with sheet metal; seal watertight.

3.5 SLEEVES

- A. Cutting, notching, bored holes and penetrations shall be in accordance with the Plumbing Code of New York State.
- B. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- C. Extend sleeves through floors one inch above finished floor level. Caulk sleeves full depth and provide floor plate.
- D. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent work with stuffing, fire stopping insulation and caulk seal air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- E. Install chrome plated steel escutcheons at finished surfaces.
- F. All penetrations shall be coordinated with General Contractor.

3.6 VIBRATION ISOLATORS

- A. Install vibration isolators for motor driven equipment and where shown or specified.

END OF SECTION 220529

SECTION 220553- PIPING IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

- A. Nameplates
- B. Tags
- C. Pipe Markers

1.2 RELATED WORK

- A. Section 220529 – Supports and Anchors
- B. Section 220700 – Piping Insulation
- C. Section 223000 – Plumbing - General

1.3 REFERENCES

- A. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.4 SUBMITTALS

- A. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Product Data: Provide manufacturers catalog literature for each product required.
- D. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

1.5 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 1.
- B. Record actual locations of tagged valves on drawings.

PART 2 – PRODUCTS

2.1 NAMEPLATES

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

2.2 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- C. Chart: Typewritten letter size list in anodized aluminum frame.

2.3 PIPE MARKERS

- A. Color: Conform to ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service. (NOTE: Use magnetically traceable to mark non-metallic piping.)

2.4 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.
- B. Color code as follows:
 - 1. Green - Plumbing valves

PART 3 EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- F. Identify pumps, water heater equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags. Key the numbers to the numbers used on the plans. Use corresponding numbers on electrical control panels, motor starters, etc.
- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. Identify valves in main and branch piping with tags.
- I. Tag automatic controls, instruments, and relays. Key to control schematic.
- J. Identify piping, concealed or exposed, with plastic pipe markers or plastic tape pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- K. Provide ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 220553

SECTION 220700- PIPING INSULATION

PART 1 – GENERAL

1.1 SCOPE

- A. Piping insulation.
- B. Jackets and accessories.

1.2 RELATED WORK

- A. Section 220529 - Supports and Anchors.
- B. Section 220553 - Piping Identification.
- C. Section 223000 - Plumbing - General.

1.3 REFERENCES

- A. ASTM Standards.
- B. NFPA Standards.
- C. UL Standards.

1.4 SUBMITTALS

- A. Submit product data: Provide product description, list of materials and thickness for each service, and locations.
- B. Manufacturer's Installation Instructions: Indicate procedures, which ensure acceptable workmanship and installation standards will be achieved.

1.5 QUALITY ASSURANCE

- A. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM, NFPA, and UL Standards.

1.6 QUALIFICATIONS

- A. Applicator: Company specializing in performing the work of this section with minimum three

years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products to site under provisions of Division 1.
- B. Deliver materials to site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic.
- D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS

2.1 GLASS FIBER

- A. Insulation: ASTM C547; rigid molded, noncombustible.
 - 1. 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees F.
 - 2. Minimum Service Temperature: -20 degrees F.
 - 3. Maximum Service Temperature: 300 degrees F.
 - 4. Maximum Moisture Absorption: 0.2 percent by volume.
- B. Vapor Barrier Jacket
 - 1. ASTM C921, White kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches.
 - 3. Secure with self sealing longitudinal laps and butt strips.
 - 4. Secure with outward clinch expanding staples and vapor barrier mastic.
- C. Tie Wire: 18 gage stainless steel with twisted ends on maximum 12 inch centers.
- D. Vapor Barrier Lap Adhesive
 - 1. Compatible with insulation.
- E. Insulating Cement/Mastic
 - 1. ASTM C195; hydraulic setting on mineral wool.

- F. Fibrous Glass Fabric
 - 1. Cloth: Untreated; 9 oz/sq yd weight.
 - 2. Blanket: 1.0 lb/cu ft density.
- G. Indoor Vapor Barrier Finish
 - 1. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.2 JACKETS

- A. PVC Plastic
 - 1. Jacket: ASTM C921, One-piece molded type fitting covers and sheet material, off white color.
 - a) Minimum Service Temperature: -40 degrees F.
 - b) Maximum Service Temperature: 150 degrees F.
 - c) Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
 - d) Maximum Flame Spread: ASTM E84; 25.
 - e) Maximum Smoke Developed: ASTM E84; 50.
 - f) Thickness: 10 mil.
 - g) Connections: Brush on welding adhesive, Tacks or Pressure sensitive color matching vinyl tape.
 - 2. Covering Adhesive Mastic
 - a) Compatible with insulation.
- B. Canvas Jacket: UL listed
 - 1. Fabric: ASTM C921, 6 oz/sq yd, plain weave cotton treated with dilute fire retardant lagging adhesive.
- C. Aluminum Jacket: ASTM B209.
 - 1. Thickness: 0.016 inch.
 - 2. Finish: Smooth.
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
 - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum, 0.010 inch thick stainless steel.
- D. Stainless Steel Jacket: Type 316 stainless steel.
 - 1. Thickness: 0.010 inch.
 - 2. Finish: Smooth.
 - 3. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

PART 3 –EXECUTION

3.1 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions.
- B. On exposed piping, locate insulation and cover seams in least visible locations.
- C. Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:
 - 1. Provide vapor barrier jackets, factory applied or field applied.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe.
 - 3. Finish with glass cloth and vapor barrier adhesive.
 - 4. PVC fitting covers may be used.
 - 5. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
 - 6. Insulate entire system.
- D. For insulated pipes conveying fluids above ambient temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - 3. Finish with glass cloth and adhesive.
 - 4. PVC fitting covers may be used.
 - 5. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- E. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert Location: Between support shield and piping and under the finish jacket.
 - 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert Material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- F. Finish insulation at supports, protrusions, and interruptions.
- G. For pipe exposed in mechanical equipment rooms or in finished spaces, finish with PVC jacket and fitting covers, stainless steel jacket.
- H. For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with stainless steel jacket with seams located on bottom side of horizontal piping.
- I. Insulate all roof drains, horizontal and vertical rain leader piping, domestic hot and cold water piping, hot water storage tanks, indirect waste and exposed water and drain piping at handicapped

lavs, sinks and water coolers.

3.3 GLASS FIBER INSULATION SCHEDULE

PIPING SYSTEMS		PIPE SIZE	THICKNESS
		Inch	Inch
A.	Plumbing Systems		
	Domestic Hot Water Supply	All	1"
	Domestic Hot Water Recirc	All	1"
	Tempered Domestic Water Supply	All	1"
	Tempered Domestic Water Recirc	All	3/4"
	Domestic Cold Water (Potable & Non-Potable)	All	1/2"
	Roof Drain Bodies	All	1"
	Roof Drainage - Horizontal & Vertical	All	1"
	Indirect Waste	All	1/2"
	Hot Water Storage Tanks	All	3"
	All hw, hwc, tw above 1 1/2" diameter		2"

END OF SECTION 220700

SECTION 223000- PLUMBING – GENERAL

PART 1 - GENERAL

1.1 SCOPE

- A. Sanitary Sewer System
- B. Domestic Water System
- C. Pipe and Pipe Fittings
- D. Valves
- E. Cleanouts

1.2 RELATED WORK

- A. Division 26 - Electrical Power Supply and Control Wiring and Connections for products provided under this Section shall be by the Division 16 Contractor.
- D. Section 220529 - Supports and Anchors
- E. Section 220533 - Piping Identification
- F. Section 220700 - Piping Insulation
- G. Section 224000 - Plumbing Fixtures

1.3 REFERENCES

- A. ANSI Standards
- B. ASME Standards
- C. ASSE Standards
- D. AWWA Standards
- E. ASTM Standards
- F. PDI Standards
- G. Local and State Building Codes
- H. American Gas Association

- I. National Electrical Code
- J. AWS Standards

1.4 SUBMITTALS

- A. Include data on pipe material, valves, drains, cleanouts, interceptors, backflow preventer, hose bibs, water heater, pressure gauges, thermometers, pumps, accessories.

1.5 QUALITY ASSURANCE

- A. Welders Certification: In accordance with ANSI/ASME Sec. 9, ANSI/AWS D1.1.
- B. Potable water supply system components, plumbing appliances, backflow prevention devices and water distribution system safety devices shall be Third-Party Certified.
- C. Sanitary, vent, and storm system plastic pipe, fittings and pipe related components shall be Third-Party Certified. All other pipe materials shall be Third-Party Tested.
- D. Special waste system components shall be Third-Party Tested.

PART 2 - PRODUCTS

2.1 SANITARY SEWER PIPING - ABOVE GRADE

- A. Cast Iron Pipe: ASTM A888, CISPI 301, hubless
Fittings: ASTM A888, CISPI 310, hubless cast iron
Joints: Neoprene gaskets and stainless steel clamp and shield assemblies
NOTE: All cast iron pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.
- B. Copper Pipe: ASTM B306, DWV
- C. Fittings: ANSI/ASME B16.3, cast bronze, or
ANSI/ASTM B32, solder, Grade Sn50

2.2 DOMESTIC WATER PIPING - ABOVE GRADE

- A. Copper Tubing: ASTM B88, Type L hard drawn
Fittings: ANSI/ASTM B16.23, cast brass or ANSI/ASME B16.29, wrought copper
Joints: ANSI/ASTM B32, solder, Grade Sn95

2.3 FLANGES, UNIONS, COUPLINGS, AND STRAINERS

- A. Pipe size 2 inches and under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
- B. Pipe size over 2 inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; neoprene gaskets for gas service.
- C. Grooves and shouldered pipe end couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular deflection, contraction and expansion; "C" shape composition sealing gasket; steel bolts, nuts and washers; galvanized couplings for galvanized pipe.
- D. Dielectric Connections: Union with galvanized or plated steel threaded end, water impervious isolation barrier.
- E. Strainers: Bronze, Epoxy coated, Cast iron "Y" type strainer, screwed end connections, flanged connections, self-cleaning, tapped for closure plug, 20 mesh stainless steel screen; manufactured by Watts or equal.

2.4 BALL VALVES

- A. Up to 2 inches: Bronze body, stainless steel ball, teflon seats and stuffing box ring, lever handle and balancing stops, solder or threaded ends with union.
- C. Over 2 inches: Cast steel body; chrome plated steel ball, Teflon seat and stuffing box seals, lever handle, flanged.

2.5 CLEANOUTS

- A. Interior Unfinished Accessible Areas (CO): Caulked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders; manufactured by Zurn or approved equal.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends, remove burrs and bevel plain end of ferrous pipe.
- B. Remove scale and dirt, inside and outside of pipe, before assembly.
- C. Remove welding slag or foreign material from pipe and fitting materials.
- D. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

3.2 INSTALLATION AND APPLICATION

- A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- B. Route piping in orderly manner and maintain gradient.
- C. Install piping to conserve building space and not interfere with use of space.
- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing piping, joints or connected equipment.
- F. Provide clearance for installation of insulation and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with General Contractor.
- H. Slope water piping and arrange to drain at low points.
- I. Establish elevations of buried piping outside the building to ensure not less than 2.5 ft. of cover.
- J. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- K. Prepare pipe, fittings, supports and accessories not prefinished, ready for finish painting.
- L. Establish invert elevations, slopes for drainage to 1/4 inch per foot for piping 3 inches & smaller and 1/8 inch per foot for piping 4 inches and larger.
- M. Excavate in accordance with Division 31.
- N. Backfill in accordance with Division 31.
- O. Install bell and spigot pipe with bell end upstream.
- P. Install valves with stems upright or horizontal, not inverted.
- Q. Use grooved mechanical couplings and fasteners only in accessible locations.
- R. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- S. Install globe valves for throttling, bypass, or manual flow control services.
- T. Install specialties in accordance with manufacturer's instructions to permit intended performance.
- U. Locate cleanouts at bases of stacks and leaders, changes in direction of more than 45 degrees on all horizontal runs, where required by Code and elsewhere as shown.

- V. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- W. Encase exterior cleanouts in concrete flush with grade.
- X. Install roof leader expansion joints on roof leaders with over a 20-foot vertical drop below roof drain and no horizontal offset immediately below drain.
- Y. Install air gap type funnel drain for reduced pressure backflow preventer relief vent. Spill over floor drain or mop basin. Drain to exterior and provide rodent screen.
- Z. Air admittance valves shall be located a minimum of four (4) inches above the weir of the fixture trap, installed in the vertical upright position and must be accessible for service, repair or replacement.

3.3 TESTS

- A. Tests and inspections shall comply with the Plumbing Code of New York State.
- B. Above Grade and Interior Buried Sanitary, Vent, Indirect Waste, Storm Piping: Seal openings; fill with water at minimum 10 feet of head and hold water level constant for two hours. Section test system so that maximum test pressure at any point in system does not exceed 40 psi. Locate test tees as required.
- C. Above Grade Interior Domestic, Water Piping: Hydrostatic test at 150 psi for two hours.

3.5 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, verify system is complete, flushed and clean.
- B. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/l residual.
- D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- E. Maintain disinfectant in systems for 24 hours.
- F. If final disinfectant residual tests less than 25 mg/l, repeat treatment.
- G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/l.
- H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C601.

END OF SECTION 223000

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SCOPE

- A. Water closet
- B. Lavatory
- C. Sink
- D. Service Sink

1.2 RELATED WORK

- A. Division 6 - Custom Casework: Preparation of counters for sinks.
- B. Division 7 - Joint Sealers: Seal fixtures to walls and floors.
- C. Division 10 - Toilet and Bath Accessories: Lavatory tops.
- D. Section 220529 - Supports and Anchors
- E. Section 223000 - Plumbing – General

1.3 REFERENCES

- A. ANSI Standards
- B. ARI Standards
- C. ADA Standards

1.4 SUBMITTALS

- A. Product data including fixtures, sizes, rough-in dimensions, utility sizes, trim and finishes.

1.5 WARRANTY

- A. Five year manufacturer's warranty of electric water cooler compressor.

1.6 QUALITY ASSURANCE

- A. Plumbing fixtures shall be Third-Party Tested.

PART 2 PRODUCTS

2.1 WATER CLOSET (WC)

- A. Bowl and tank: floor mounted, vitreous china closet bowl/tank type, with elongated rim, 1.28 gallon flush, china bolt caps; Model manufactured by American Standard or approved equal.
- B. Seat: Solid white plastic, open front, extended back, self-sustaining hinge, brass bolts, without cover; Model 9500 SSC manufactured by Church or equal.

2.2 LAVATORY (LAV)

- A. Bowl: rectangular wall mounted vitreous China with 4 inch center faucet, with ADA compliant single lever chrome swivel faucet complete with rough in supplies and chrome waste trap assembly. Manufactured by American Standard, model approved equal. Single lever faucet manufactured by Delta model or approved equal.

2.3 SINK (SK)

- A. Bowl: Single bin, 18"x 18" counter mounted 304 stainless steel with (1) 4 inch center knock outs for faucets, with ADA compliant dual lever chrome swivel faucet complete with rough in supplies and chrome waste trap assembly. Manufactured by Elkay or approved equal. Faucet manufactured by Delta or approved equal.

2.4 SERVICE SINK (SS)

- A. Plastic service/ laundry style sink with 4" center faucet included, free standing, 4 leg manufactured by Mustee # 19CF or equal

PART 3 EXECUTION

3.1 INSPECTION

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.
- B. Verify adjacent construction is ready to receive rough-in work of this Section.

3.2 INSTALLATION

- A. Install each fixture with trap, easily removable for servicing and cleaning.

- B. Provide chrome plated rigid or flexible supplies to fixtures with loose key stops reducers, and escutcheons.
- C. Install components level and plumb
- D. Install and secure fixtures in place with wall carriers and bolts.
- E. Seal fixtures to wall and floor surfaces with sealant, color to match fixture.
- F. Repair leaky faucets and valves prior to final inspection.
- G. Coordinate work with other trades.
- H. Mount fixtures to the following heights above finished floor:

Water Closet:

Standard	15 inches to top of bowl rim.
Handicapped	18 inches to top of seat.

Lavatory:

Standard	30 inch clearance at apron.
Handicapped	31 inch clearance at apron.

3.3 ADJUSTING AND CLEANING

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.
- B. At completion clean plumbing fixtures and equipment.

3.4 FIXTURE ROUGH-IN SCHEDULE

- A. See drawings

END OF SECTION

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC 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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230514 -ELECTRIC WIRING FOR HVAC EQUIPMENT

PART I-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 WORK INCLUDED

- A. Provide "control" wiring circuits for equipment and associated control devices, and control panels including standalone control panels and terminal equipment controllers.
- B. Provide certain "power" wiring as called for.
- C. Assistance, as required, and coordination with Division 26, "Electric."

1.3 WORK NOT INCLUDED

- A. Power wiring for motors, motor starters and associated starting equipment, as well as mounting of motor starters and devices, is included in Division 26, "Electric."

1.4 QUALIFICATIONS

- A. Wiring installed in compliance with NEC, local governing codes, and applicable requirements of Division 26, "Electric."

1.5 COORDINATION

- A. Provide complete wiring diagrams for equipment and systems. Deliver wiring diagrams to proper parties in time for roughing of conduit, equipment connections, and avoid delay in construction schedule. Wiring diagrams and roughing information to clearly indicate items to be mounted and/or wired as part of the Work of Division 26, "Electric."

PART 2 - PRODUCTS

2.1 WIRING MATERIALS

- A. Materials:
 - 1. Rigid conduit, hot dipped, galvanized steel with galvanized, threaded malleable

- iron fittings.
- 2. Metallic type (EMT), low carbon steel, with galvanized steel compression type, concrete tight fittings.
- 3. Flexible conduit, steel interlock type, galvanized, with galvanized steel fittings, plastic coated in wet locations, (Crawl spaces, outdoors).
- 4. Boxes and Fittings: Conduit style in damp or wet locations. Other locations; galvanized, stamped steel type or conduit type.
- 5. Wire: Annealed copper, 98% conductivity. #12 AWG minimum size for branch circuit and emergency system wiring; #14 AWG minimum size for 120 volt control circuits and #16 AWG for low voltage control circuits unless otherwise called for.
- 6. Insulation: Type THHN. Power feeders and branch circuits rated 230 volts and under color-coded red, black and blue with white neutral conductor. Power feeders and branch circuits rated 240 volts to 480 volts color coded orange, brown and yellow, with gray neutral conductor.

2.2 SHIELDED INSTRUMENTATION WIRING

- A. Suitable for analog input and output devices; #16 AWG twisted shielded pair.

PART 3 - EXECUTION

3.1 GENERAL

- A. Check electrical wiring pertaining to equipment for completeness and correctness of connections. Correct any misapplied motor and/or motor starter, improper thermal overload device, or device which fails to function and resultant damage, whether due to incorrect connections or improper information on wiring diagrams.

3.2 WIRING FOR CONTROL SYSTEMS

- A. Provide control and instrumentation wiring for equipment.
- B. Wiring circuits shall be in conduit. Rigid type below slabs, wet locations, exposed to weather and hazardous locations. EMT in dry, nonhazardous locations for concealed or exposed Work. Provide 18 in. minimum length flexible conduit at motors and device subject to vibration. Conduit supported on 5 ft. centers. Do not attach directly to hot surfaces, piping, or ductwork.
- C. Control wiring shall be in separate conduit from power wiring.
- D. Provide green grounding wire circuits from starter, and run ground wire through conduit to each remote auxiliary relay, pushbutton station, remote panel heating device, thermostat, or device with potentials in excess of 50 volts contained within. Size ground wire per NEC.

- E. Where allowable by code, Teflon coated insulated wire may be provided in accessible ceiling plenums for low voltage control systems.

3.3 SURFACE RACEWAYS

- A. Provide surface raceway in areas without ceiling (non-mechanical rooms) and where exposed to wood deck.
- B. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
- D. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

3.4 FIELD WIRING IN STARTERS, CONTROLLERS, AND PANELS

- A. Wiring within starters, controllers, and temperature control panels, shall be routed neatly in gutter space, away from moving and/or heat producing parts.
- B. Provide 30 ampere, 600 volt rated terminal blocks. Do not place more than two wire connections on pilot device or relay terminal. Where more than two circuit connections are required, use terminal blocks.
- C. Provide nylon self-insulated, locking type spade lugs for all control wires.
- D. Cables and wires shall be neatly bundled and lashed with nylon cable straps.

END OF SECTION 230514

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball valves.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene-propylene-diene monomer.
- C. FKM: Fluoroelastomer.
- D. NBR: Nitrile butadiene rubber (also known as "Buna-N").
- E. NRS: Nonrising stem.
- F. OS&Y: Outside screw and yoke.
- G. PTFE: Polytetrafluoroethylene.
- H. RPTFE: Reinforced polytetrafluoroethylene.
- I. RS: Rising stem.
- J. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include material descriptions and dimensions of individual components.
 2. Include operating characteristics and furnished accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
 3. Set ball valves open to minimize exposure of functional surfaces.
 4. Block check valves in either closed or open position.

5. Set gate valves closed to prevent rattling.
6. Set plug valves to open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

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

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast-copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
7. ASME B16.34 for flanged- and threaded-end connections.
8. ASME B16.51 for press joint connections.
9. ASME B31.1 for power piping valves.
10. ASME B31.9 for building services piping valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Type:

1. Hand Lever: For quarter-turn ball valves smaller than NPS 4

G. Valves in Insulated Piping:

1. Provide 2-inch extended neck stems.
2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 BALL VALVES

A. Ball Valves, Threaded or Soldered Ends - Brass, Two Piece with Full Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. American Valve, Inc
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. Crane Fluid Systems; Crane Co.
 - d. Hammond Valve
 - e. Lance Valves
 - f. Legend Valve & Fitting, Inc
 - g. Milwaukee Valve Company
 - h. Red-White Valve Corp.
 - i. Viega LLC
2. Standard: MSS SP-110.
3. CWP Rating: 600 psig
4. Body Design: Two piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for

proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

- E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.
- H. Valve Tags: Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."
- I. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
4. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.

3.5 CHILLED-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Ball valves, threaded or soldered ends - brass, two piece with full port and stainless steel trim; threaded or soldered ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.

3.6 HEATING-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Ball valves, threaded or soldered ends - brass, two piece with full port and brass trim; threaded or soldered ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 150.

3.7 PUMP-DISCHARGE CHECK VALVE SCHEDULE

- A. Chilled-Water Pump Discharge:
 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
 3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
 - a. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
 4. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
 - a. Check valves, swing type, grooved ends - iron, 300 CWP.
- B. Heating-Water Pump Discharge:
 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Check valves, swing type, threaded or soldered ends - bronze, with bronze disc, Class 150.

2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
 - a. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
4. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
 - a. Check valves, swing type, grooved ends - iron, 300 CWP.

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.
3. Valve tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve-numbering scheme.
- E. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. Craftmark Pipe Markers
 - d. LEM Products Inc.
 - e. Pipemarket.com; Brimar Industries, Inc.
 - f. Seton Identification Products; a Brady Corporation company
2. Material and Thickness: Brass, 0.032-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
3. Letter and Background Color: As indicated for specific application under Part 3.

4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.
6. Fasteners: Stainless steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Brady Corporation
 2. Carlton Industries, LP
 3. Craftmark Pipe Markers
 4. LEM Products Inc.
 5. Pipemarker.com; Brimar Industries, Inc.
 6. Seton Identification Products; a Brady Corporation company
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- F. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 1. Pipe size.
 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.3 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Brady Corporation
 2. Carlton Industries, LP
 3. Craftmark Pipe Markers
 4. LEM Products Inc.

5. Pipemarker.com; Brimar Industries, Inc.
 6. Seton Identification Products; a Brady Corporation company
- B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. 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. Include valve-tag schedule in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION, GENERAL REQUIREMENTS

- 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.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS

- A. Permanently fasten labels on each item of mechanical equipment.
- B. Sign and Label Colors:
1. White letters on an ANSI Z535.1 safety-blue background.
- C. Locate equipment labels where accessible and visible.

- D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E.

3.4 INSTALLATION OF PIPE LABELS

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- C. Pipe-Label Locations: 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. Within 3 ft. of each valve and control device.
 - 2. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 3. Within 3 ft. of equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.
- D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- E. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- F. Pipe-Label Color Schedule:
 - 1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 - 2. Condenser-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 - 3. Heating Water Piping: White letters on an ANSI Z535.1 safety-green background.

3.5 INSTALLATION OF VALVE TAGS

- A. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.
 - 1. Valve-Tag Size and Shape:
 - a. Chilled Water: 1-1/2 inches, square.
 - b. Hot Water: 1-1/2 inches, square.
 - 2. Valve-Tag Colors:
 - a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
 - a. Variable-flow hydronic systems.
2. Testing, adjusting, and balancing of equipment.
3. Testing, adjusting, and balancing of existing HVAC systems and equipment.
4. HVAC-control system verification.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.
- G. UFAD: Underfloor air distribution.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist 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. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. 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.

1.4 QUALITY ASSURANCE

- A. TAB Specialists Qualifications, Certified by AABC:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC.
- B. TAB Specialists Qualifications, Certified by NEBB or TABB:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
 - 1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.5 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, available TAB specialists that may be engaged include, but are not limited to, the following:
 - 1. New York Technologies Corp.
 - 2. OR Approved Equal

3.2 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. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data, including fan and pump curves.
 - 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.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- I. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

- J. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- L. Examine system pumps to ensure absence of entrained air in the suction piping.
- M. Examine operating safety interlocks and controls on HVAC equipment.
- N. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.
- O. 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.

3.3 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. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.
 - 2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.

- e. Strainers are pulled and cleaned.
- f. Control valves are functioning in accordance with the sequence of operation.
- g. Shutoff and balance valves have been verified to be 100 percent open.
- h. Pumps are started and proper rotation is verified.
- i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- j. Variable-frequency controllers' startup is complete and safeties are verified.
- k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
- 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).

3.5 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

- A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Pumps.
 - 3. Fans and ventilators.
 - 4. Boilers.
 - 5. Unit heaters.
 - 6. Water chillers.
 - 7. Air-handling units.
 - 8. Coils.
 - 9. Unit ventilators.

3.6 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' Record drawings duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.

3.7 PROCEDURES FOR MULTIZONE SYSTEMS

- A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.
- B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.
- C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.
- D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 - c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible

- connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Obtain approval from Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- F. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlet and outlet airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- G. Verify final system conditions.
 - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - 2. Re-measure and confirm that total airflow is within design.
 - 3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
 - 4. Mark all final settings.
 - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 - 6. Measure and record all operating data.
 - 7. Record final fan-performance data.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' Record drawings piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check expansion tank for proper setting.
 2. Check highest vent for adequate pressure.
 3. Check flow-control valves for proper position.
 4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
 5. Verify that motor controllers are equipped with properly sized thermal protection.
 6. Check that air has been purged from the system.
- D. Measure and record upstream and downstream pressure of each piece of equipment.
- E. Measure and record upstream and downstream pressure of pressure-reducing valves.
- F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
1. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
1. Verify that the pressure-differential sensor(s) is located as indicated.
 2. Determine whether there is diversity in the system.
- C. For systems with no flow diversity:
1. Adjust pumps to deliver total design flow.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve or

speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

- c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
2. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:
 - a. Re-measure and confirm that total flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 - c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
 - c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
5. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
6. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature

- method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- 7. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
- 8. Prior to verifying final system conditions, determine system pressure-differential set point(s).
- 9. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
- 10. Mark final settings and verify that memory stops have been set.
- 11. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 - c. Mark final settings.

3.10 PROCEDURES FOR MOTORS

- A. Motors ½ HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer's name, model number, and serial number.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Phase and hertz.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter size and thermal-protection-element rating.
 - 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 PROCEDURES FOR WATER CHILLERS

- A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.

3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
5. Capacity: Calculate in tons of cooling.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
7. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.

3.12 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each hydronic coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

3.13 DUCT LEAKAGE TESTS

- A. Witness the duct leakage testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.14 PIPE LEAKAGE TESTS

- A. Witness the pipe pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.15 HVAC CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
1. Verify HVAC control system is operating within the design limitations.
 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 3. Verify that controllers are calibrated and function as intended.
 4. Verify that controller set points are as indicated.
 5. Verify the operation of lockout or interlock systems.

6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.16 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
 2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
 3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 4. Check the condition of filters.
 5. Check the condition of coils.
 6. Check the operation of the drain pan and condensate-drain trap.
 7. Check bearings and other lubricated parts for proper lubrication.
 8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:
1. New filters are installed.
 2. Coils are clean and fins combed.
 3. Drain pans are clean.
 4. Fans are clean.
 5. Bearings and other parts are properly lubricated.
 6. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
 2. Verify that the indicated airflows of the renovated work result in filter and coil face

- velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
 4. Balance each air outlet.

3.17 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent If design value is less than 100 cfm, within 10 cfm.
 2. Air Outlets and Inlets: Plus or minus 10 percent If design value is less than 100 cfm, within 10 cfm.
 3. Heating-Water Flow Rate: Plus or minus 10 percent If design value is less than 10 gpm within 10 percent.
 4. Chilled-Water Flow Rate: Plus or minus 10 percent If design value is less than 10 gpm within 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.18 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-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.

3.19 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. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop

Drawings and Product Data.

- 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 specialist.
 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 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. Heating coil, dry-bulb conditions.
 - e. Face and bypass damper settings at coils.
 - f. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - g. Variable-frequency controller settings for variable-air-volume systems.
 - h. Settings for pressure controller(s).
 - i. Other system operating conditions that affect performance.
 16. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. 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 and steam flow rates.
 3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches .
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches , and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm .
 - b. Total system static pressure in inches wg .
 - c. Fan speed.
 - d. Inlet and discharge static pressure in inches wg .
 - e. For each filter bank, filter static-pressure differential in inches wg .
 - f. Cooling-coil static-pressure differential in inches wg .
 - g. Heating-coil static-pressure differential in inches wg .
 - h. List for each internal component with pressure-drop, static-pressure differential in inches wg .
 - i. Outdoor airflow in cfm .
 - j. Return airflow in cfm .
 - k. Outdoor-air damper position.
 - l. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm .
- b. Average face velocity in fpm .
- c. Air pressure drop in inches wg .
- d. Outdoor-air, wet- and dry-bulb temperatures in deg F .
- e. Return-air, wet- and dry-bulb temperatures in deg F .
- f. Entering-air, wet- and dry-bulb temperatures in deg F .
- g. Leaving-air, wet- and dry-bulb temperatures in deg F .
- h. Water flow rate in gpm (L/s).
- i. Water pressure differential in feet of head or psig (kPa).
- j. Entering-water temperature in deg F (deg C).
- k. Leaving-water temperature in deg F (deg C).

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and size.
- e. Manufacturer's serial number.
- f. Arrangement and class.
- g. Sheave make, size in inches , and bore.
- h. Center-to-center dimensions of sheave and amount of adjustments in inches .

2. Motor Data:

- a. Motor make, and frame type and size.
- b. Horsepower and speed.
- c. Volts, phase, and hertz.
- d. Full-load amperage and service factor.
- e. Sheave make, size in inches , and bore.
- f. Center-to-center dimensions of sheave and amount of adjustments in inches .
- g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm .
- b. Total system static pressure in inches wg .
- c. Fan speed.
- d. Discharge static pressure in inches wg .
- e. Suction static pressure in inches wg .

H. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:

- a. Unit identification.

- b. Location.
- c. Service.
- d. Make and size.
- e. Model number and serial number.
- f. Water flow rate in gpm .
- g. Water pressure differential in feet of head or psig .
- h. Required net positive suction head in feet of head or psig .
- i. Pump speed.
- j. Impeller diameter in inches .
- k. Motor make and frame size.
- l. Motor horsepower and rpm.
- m. Voltage at each connection.
- n. Amperage for each phase.
- o. Full-load amperage and service factor.
- p. Seal type.

2. Test Data (Indicated and Actual Values):

- a. Static head in feet of head or psig .
- b. Pump shutoff pressure in feet of head or psig .
- c. Actual impeller size in inches .
- d. Full-open flow rate in gpm .
- e. Full-open pressure in feet of head or psig .
- f. Final discharge pressure in feet of head or psig .
- g. Final suction pressure in feet of head or psig .
- h. Final total pressure in feet of head or psig .
- i. Final water flow rate in gpm .
- j. Voltage at each connection.
- k. Amperage for each phase.

I. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.20 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner
- B. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

- C. 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."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
 - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
 - 2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.
- F. Prepare test and inspection reports.

3.21 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.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230900 - INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1: GENERAL

1.1 Related Sections

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

1.2 Description

- A. This project shall be an extension of the existing Tridium Niagara Building Automation System. Any newly installed controls equipment shall be fully integrated into the existing system for Control, Alarming, Trending and History. It shall be the responsibility of the BMS Contractor to accomplish the integration without the use of Gateways or proprietary software.
- B. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.
- C. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet.
The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.
- D. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in 230900 – Sequence of Operations Section 3.20 shall be BACnet objects.

1.3 Approved Control system Manufacturers

- A. This project is designed as an extension of the existing Tridium Niagara system. The complete Building Management System is designed and based on an open protocol system using the Niagara Framework. All hardware must be BTL listed and communicate using BACnet IP or MS/TP.
- B. Subject to compliance with requirements, provide products and services by one of the following or approved alternate:
 - 1. Tridium Vykon
 - 2. Honeywell Webs/Optimizer
- C. The above list does not indicate order of preference. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

1. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.
2. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.4 Quality Assurance

A. Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer.
2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.
3. Controls contractor shall have service office within 50 miles of the airport property.
4. Controls contractor shall have a minimum of (5) Niagara Certified individuals.

1.5 Codes and Standards

- ##### A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:
1. National Electric Code (NEC)
 2. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.6 System Performance

- ##### A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using the manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).
1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
 2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
 3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
 4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
 5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
 6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
 7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.

8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table

Table-1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C (±1°F)
Ducted Air	±0.5°C (±1°F)
Outside Air	±1.0°C (±2°F)
Dew Point	±1.5°C (±3°F)
Water Temperature	±0.5°C (±1°F)
Delta-T	±0.15° (±0.25°F)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical	±1% of reading (see Note 3)
Carbon Dioxide (CO ₂)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale.

Note 2: For both absolute and differential pressure.

Note 3: Not including utility-supplied meters.

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.7 Submittals

- A. Product Data and Shop Drawings: Meet requirements of Section 013000 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as PDF files and three 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve the Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of the contract award. Submittals shall include:

1. DDC System Hardware

- a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
- b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
 - i. Direct digital controllers (controller panels)
 - ii. Transducers and transmitters
 - iii. Sensors (including accuracy data)
 - iv. Valves
 - v. Relays and switches
 - vi. Control panels
 - vii. Operator interface equipment
 - viii. Wiring
- c. Wiring diagrams and layouts for each control panel. Show termination numbers.
- d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software

- a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.
- b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
 - i. Central Processing Unit (CPU) or web server
 - ii. Monitors
 - iii. Keyboards
 - iv. Power supplies
 - v. Battery backups
 - vi. Interface equipment between CPU or server and control panels
 - vii. Operating System software
 - viii. Operator interface software
 - ix. Color graphic software

- x. Third-party software
- c. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
- d. Network riser diagrams of wiring between central control unit and control panels.
- 3. Controlled Systems
 - a. Riser diagrams showing control network layout, communication protocol, and wire types.
 - b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
 - c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
 - d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
 - e. A mounting, wiring, and routing plan-view drawing. The design shall consider HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
 - f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
 - g. A point list for each control system. List I/O points and software points specified in Section 23 09 93. Indicate alarmed and trended points.
- 4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
- 5. A description of the proposed process along with all report formats and checklists to be used in Section 23 09 23 Article 3.17 (Control System Demonstration and Acceptance).
- 6. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.
- B. Schedules
 - 1. Within one month of contract award, provide a schedule of the work indicating the following:
 - a. Intended sequence of work items
 - b. Start date of each work item
 - c. Duration of each work item
 - d. Planned delivery dates for ordered material and equipment and expected lead times.
 - e. Milestones indicating possible restraints on work by other trades or situations.
 - 2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.
- C. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as PDF files and as 11" x 17" prints.
 2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Section 23 09 23 Article 3.17 (Control System Demonstration and Acceptance).
 3. Operation and Maintenance (O&M) Manual.
 4. As-built versions of submittal product data.
 5. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 6. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
 7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
 9. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
 10. Graphic files, programs, and database on magnetic or optical media.
 11. List of recommended spare parts with part numbers and suppliers.
 12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
 14. Licenses, guarantees, and warranty documents for equipment and systems.
 15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- D. Training Materials: Provide course outline and materials for each class at least six weeks before the first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. The engineer will review and approve course outlines and materials at least three weeks before the first class.

1.8 Warranty

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If the engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.9 Controller Security Capabilities

- A. Each building level controller must be fully capable of utilizing and storing a customer-based security certificate, certificate must be matching and loaded at the head-end and fully utilized for encrypted certificate communication for every packet transmission. Main head-end computer must be vendor agnostic and open 3rd party integrated control systems. TLS encryption will be utilized for all network transmissions.
- B. Controller accounts and permissions will be a 1:M (ONE TO MANY RELATIONSHIP); customer will be able to change the local controller credentials in a single location which then are appropriately pushed to all controllers throughout the entire system.
- C. Trend logs, schedules, point data will all be transferred in the secured and encrypted protocol. At no point should any communications be passed as unsecured or "open" traffic.
- D. Polling and tuning policies will be modified and adjusted per the network traffic optimization efforts; network barometers will be utilized to determine saturation level to maintain overall bandwidth at point of installation.
- E. IP Controllers shall be fully capable of holding a lease reservation within the customer-provided network.
- F. Programming tools for all controllers must be installed locally within the customer and licensed.

1.10 Ownership of Proprietary Material

- A. Project-specific software and documentation shall become the Owner's property. This includes, but is not limited to:
 1. Graphics
 2. Record drawings
 3. Database
 4. Application programming code
 5. Documentation

1.11 Definitions

Term	Definition
BACnet Interoperability Building Blocks (BIBB)	A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specific application.
BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
Control Systems Server	A computer(s) that maintain(s) the systems configuration and programming database.
Controller	Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.
Direct Digital Control	Microprocessor-based control including Analog/Digital conversion and program logic.
Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.
Local Area Network	Computer or control system communications network limited to local building or campus.
Master-Slave/Token Pass-Point-to-Point	Data link protocol as defined by the BACnet standard.
Primary Controlling LAN	Serial communication as defined in the BACnet standard.
Protocol Implementation Conformance Statement	High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.
Router	A written document that identifies the particular options specified by BACnet that are implemented in a device.
Wiring	A device that connects two or more networks at the network layer.
	Raceway, fittings, wire, boxes and related items.

2.1 Materials

- A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 Communication

- A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.
- B. Install new wiring and network devices as required to provide a complete and workable control network.
- C. Use existing Ethernet backbone for network segments marked "existing" on project drawings.
- D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
 - 1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
 - 2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 23 09 93. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.
- E. Workstations, Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.
- F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.
- G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
 - 1. The system shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
 - 2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
 - 3. For read or write requests, the system shall require username and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.

4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third-party Web services device to read data from or write data to any object in the system which supports this service.

2.3 Operator Interface

- A. Operator Interface. Web server shall reside on high-speed network with building controllers. Each standard browser connected to the server shall be able to access all system information. The Operator Workstation or server shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L.
- B. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.
- C. Hardware.
 1. Workstation or web server. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The following hardware requirements also apply:
 - a. The hard disk shall have sufficient memory to store:
 - i. All required operator workstation software.
 - ii. A DDC database at least twice the size of the delivered system database.
 - iii. One year of trend data based on the points specified to be trended at their specified trend intervals.
 - b. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.
 - c. Minimum hardware configuration shall include the following:
 - i. 8-16 Core Processor
 - ii. 16 GB RAM
 - iii. 1 TB hard disk providing data at 3.0 Gb/sec.
 - iv. 16x DVD+/-RW drive
 - v. Serial, parallel, and network communication ports and cables as required for proper DDC system operation.
- D. System Software.
 1. Operating System. Web server or workstation shall have an industry-standard professional-grade operating system. The operating system shall meet or exceed the DDC System manufacturers minimum requirements for their software. Acceptable systems include Microsoft Windows 10 or 11, Windows Server 2018, Red Hat Enterprise Linux, or Ubuntu Desktop 12.04.
 2. System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract.
 - a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of

- equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
- b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
- c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
- d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins (such as Adobe Flash).
- 3. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.
- 4. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
- E. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.
 - 1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
 - 2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
 - 3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.
 - 4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. Online help shall be available for all applications and shall provide the relevant data for that screen. Additional help information shall be available using hypertext.
 - 5. Security. Each operator shall be required to log on to the system with username and password to view, edit, add, or delete data.
 - a. Operator Access. The username and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System Administrators shall also be able to vary and deny each operator's privileges based on the geographic location of the equipment, such as the ability to edit operating parameters in

Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.

- b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
 - c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
6. System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 230900 (Sequences of Operation). Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms or mnemonics.
9. Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms and archive closed alarms to the workstation or web server hard disk.
11. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. The controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Section 23 09 93 (Sequences of Operation). Trends shall be BACnet trend objects.
12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:
 - a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
 - b. Alarm Summary. Current alarms and closed alarms. The system shall retain closed alarms for an adjustable period.
 - c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
 - i. Alarm History.

- ii. Trend Data. Operator shall be able to select trends to be logged.
 - iii. Operator Activity. At a minimum, the system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.
- F. Workstation Application Editors. Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.
 - 1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
 - 2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.
 - 3. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
 - a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
 - b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
 - c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
 - d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operators shall be able to adjust input variables to simulate actual operating conditions. Operators shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
 - e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
 - g. Variables. Operator shall be able to use variable values in program conditional statements and mathematical functions.
 - i. Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date.

Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

- ii. System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.
- G. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

2.4 Controller Software

- A. Furnish the following applications for building and energy management. All software applications shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.
- B. System Security. See Paragraph 2.3.E.5 (Security) and Paragraph 2.3.E.14.c.iii (Operator Activity).
- C. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:
 - 1. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
 - 2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has been executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
 - 3. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.
- D. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.
- E. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
- F. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.
- G. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.
- H. Remote Communication. The system shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, the system shall use a modem connection.
- I. Demand Limiting.

1. The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to monitor a watt transducer or current transformer attached to the building feeder lines.
 2. When power consumption exceeds adjustable levels, the system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in Section 230900 (Sequences of Operation). When demand drops below adjustable levels, the system shall restore loads as specified.
- J. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in 230900 (Sequences of Operation).
- K. Sequencing. Application software shall sequence equipment as specified in Section 230900 (Sequences of Operation).
- L. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.
- M. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.
- N. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.
- O. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.
- P. Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Section 230900 (Sequence of Operations).

2.5 Controllers

- A. Standalone Controllers shall provide control of HVAC where called for in the design. Each controller shall have its own control programs and shall continue to operate in the event of a failure or communication loss to its associated Network Controllers.
- B. Standalone Controllers shall provide a communication port to the field bus.
- C. Each controller shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.

- D. Each Standalone Controller shall support the addition of the following types of inputs and outputs:
1. Digital Inputs for status/alarm contacts.
 2. Counter Inputs for summing pulses from meters.
 3. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
 4. Analog inputs for pressure, humidity, flow and position measurements.
 5. Digital Outputs for on/off equipment control.
 6. Analog Outputs for valve and damper position control, and capacity control of primary equipment.
- E. Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two (2) modules shall be added to the base Standalone Controller before additional power is required.
- F. Each Standalone Controller shall be able to exchange information on a peer to peer basis with other Standalone Controllers during each field bus scan. Each Standalone Controller shall be capable of storing and referencing global variables (on the LAN) with or without any Supervisors online. Each Standalone Controller shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a Supervisor connected to a Network Controller.
- G. Standalone Controllers shall have as a minimum, LED indication of CPU status, and field bus status.
- H. Standalone Controllers shall have a real time clock in either hardware or software. The Real Time Clock shall provide the following information: time of day, day, month, year, and day of week. Each Standalone Controller shall receive a signal over the network from the Network Controllers, which synchronizes all Standalone Controllers real time clocks.
- I. Upon restoration of power, the Standalone Controller shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.
- J. Each Standalone Controller shall have at least three (3) years of battery back up to maintain all volatile memory if necessary.
- K. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Standalone Controllers and can result in the display of one or more alarm messages or reports.

1. Up to eight (8) alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.
 2. Alarm messages can be sent to a local terminal or modem connected to a Network Controller or to the Operator's Supervisor(s).
 3. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.
 4. If communication with the Network Controller is temporarily interrupted, the alarm shall be saved in the Standalone Controller. When communications return, the alarm shall be transmitted to the Network Controller if the point is still in the alarm condition.
- L. Air Handler Controllers shall be capable of meeting the requirements of the sequence of operation intended for each system and allow for future expansion.
1. Air Handling Unit Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
 2. Air Handling Unit Controllers shall be fully user programmable to allow for modification of the application software.
 3. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.
- M. Air Terminal Unit Controllers:
1. Air Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of Air Terminal Units to address current requirements as described in the Execution portion of this specification, and for future expansion:
 - a. Single Duct Cooling Only
 - b. Single Duct Cooling with Reheat (Electric or Hot Water)
 - c. Fan Powered (Parallel or Series)
 - d. Dual Duct (Constant or Variable Volume)
 - e. Supply/Exhaust
 2. Air Terminal Unit Controllers for single duct applications shall be provided with a built-in actuator for modulation of the air damper. The actuator shall contain an override mechanism for manual positioning of the damper during startup and service.
 3. Air Terminal Unit Controllers shall contain an integral velocity sensor.

4. Each controller shall perform the sequence of operation as determined by the Engineer, and have the capability for time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending.
5. Air Terminal Unit Controllers shall be able to communicate with any other Standalone Controllers on the same field bus with or without communication to the Network Controllers managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 Air Terminal Unit Controllers per field bus.

N. Unitary Controllers:

1. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:
 - a. Unit Ventilators
 - b. Heat Pumps (Air to Air, Water to Water)
 - c. Packaged Rooftops
 - d. Fan Coils (2 or 4 Pipe)
2. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation determined by the Engineer. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

2.6 Power Supplies and Line Filtering

- A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
 1. DC power supply output shall match output current and voltage requirements. The unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. The regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.
 - a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA listed.
- B. Power Line Filtering.
 1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
 - a. Dielectric strength of 1000 V minimum
 - b. Response time of 10 nanoseconds or less
 - c. Transverse mode noise attenuation of 65 dB or greater
 - d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

2.7 Auxiliary Control Devices

- A. Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follows.
 - 1. Type. Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings.
 - a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
 - b. Other modulating dampers shall be opposed blades.
 - c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.
 - 2. Frame. Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (1/8 in.) extruded aluminum with reinforced corner bracing.
 - 3. Blades. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 1.5875 mm (16 gauge).
 - 4. Shaft Bearings. Damper shaft bearings shall be as recommended by the manufacturer for application, oil impregnated sintered bronze, or better.
 - 5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m² (10 cfm per ft²) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
 - 6. Sections. Individual damper sections shall not exceed 125 cm × 150 cm (48 in. × 60 in.). Each section shall have at least one damper actuator.
 - 7. Modulating dampers shall provide a linear flow characteristic where possible.
 - 8. Linkages. Dampers shall have exposed linkages.
- B. Electric Damper and Valve Actuators.
 - 1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
 - 2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
 - 3. Signal and Range. Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)
 - 4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
 - 5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.
- C. Control Valves.
 - 1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
 - 2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - a. Water Valves:

- i. Two-way: 150% of total system (pump) head.
 - ii. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
- 3. Water Valves.
 - a. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
 - b. Sizing Criteria:
 - i. Two-position service: Line size.
 - ii. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
 - iii. Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.
 - iv. Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless-steel ball.
 - v. Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
 - c. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
 - i. Water zone valves—normally open preferred.
 - ii. Heating coils in air handlers—normally open.
 - iii. Chilled water control valves—normally closed.
 - iv. Other applications—as scheduled or as required by sequences of operation.
- D. Binary Temperature Devices.
 - 1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 - 2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 - 3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.
- E. Temperature Sensors.
 - 1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

2. Duct Sensors. Duct sensors shall be single point or average as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross-section.
 3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well the pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
 4. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
 5. Differential Sensors. Provide matched sensors for differential temperature measurement.
- F. Humidity Sensors.
1. Duct and room sensors shall have a sensing range of 20%–80%.
 2. Duct sensors shall have a sampling chamber.
 3. Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°C–75°C (-40°F–170°F).
 4. Humidity sensors shall not drift more than 1% of full scale annually.
- G. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
 2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- H. Relays.
1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
 2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable $\pm 100\%$ from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.
- I. Override Timers.
1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6-hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.
- J. Current Transmitters.
1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with a two or three wire 2–10 Vdc or 4–20 mA output signal. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be $\pm 1\%$ full-scale at 500-ohm maximum burden.
 2. The Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
 3. Unit shall be split-core type for clamp-on installation on existing wiring.
- K. Current Transformers.
1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

2. Transformers shall be available in various current ratios and shall be selected for $\pm 1\%$ accuracy at 5 A full-scale output.
 3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.
- L. Voltage Transmitters.
1. AC voltage transmitters shall be a two or three wire 2–10 Vdc or 4–20 mA output signal with zero and span adjustment.
 2. Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be $\pm 1\%$ full-scale at 500-ohm maximum burden.
 3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.
- M. Voltage Transformers.
1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
 2. Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide $\pm 0.5\%$ accuracy at 24 Vac and 5 VA load.
 3. Windings (except for terminals) shall be completely enclosed with metal or plastic.
- N. Power Monitors.
1. Selectable rate pulse output for kWh reading, a two or three wire 2–10 Vdc or 4–20 mA output signal for kW reading, N.O. alarm contact, and ability to operate with 5.0-amp current inputs or 0–0.33-volt inputs.
 2. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120–600 V, and auto range select.
 3. Under voltage/phase monitor circuitry.
 4. NEMA 1 enclosure.
 5. Current transformers have a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.
- O. Hydronic Flowmeters
1. Insertion-Type Turbine Meter
 - a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
 - b. Insertion types complete with 'hot tap' isolation valves to enable sensor removal without water supply system shutdown.
 - c. Sensing method shall be impedance sensing (nonmagnetic and non-photoelectric)
 - d. Volumetric accuracy
 - i. $\pm 0.5\%$ of reading at calibrated velocity
 - ii. $\pm 1\%$ of reading from 3 to 30 ft/s (10:1 range)
 - iii. $\pm 2\%$ of reading from 0.4 to 20 ft/s (50:1 range)
 - e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

- f. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
 - g. All wetted metal parts shall be constructed of 316 stainless steel.
 - h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.
2. Magnetic Flow-Tube Type Flowmeter
- a. The sensor shall be a magnetic flowmeter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor, and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
 - b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
 - c. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. The output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
 - d. Flow Tube:
 - i. ANSI class 150 psig steel
 - ii. ANSI flanges
 - iii. Protected with PTFE, PFA, or ETFE liner rated for 245°F minimum fluid temperature.
 - e. Electrode and grounding material
 - i. 316L Stainless steel or Hastelloy C
 - ii. Electrodes shall be fused to ceramic liner and not require O-rings.
 - f. Electrical Enclosure: NEMA 4, 7
 - g. Approvals:
 - i. UL or CSA
 - ii. NSF Drinking Water approval for domestic water applications.
 - h. Performance
 - i. Accuracy shall be $\pm 0.5\%$ of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
 - ii. Stability: 0.1% rate over six months.
 - iii. Meter repeatability shall be $\pm 0.1\%$ of rate at velocities > 3 ft/s.
3. Magnetic Insertion-Type Flowmeter
- a. Magnetic Faraday point velocity measuring device.
 - b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
 - c. 4-20 mA transmitter proportional to flow or velocity.
 - d. Accuracy: larger of 1% of reading and 0.2 ft/s.
 - e. Flow range: 0.2 to 20 ft/s, bidirectional.
 - f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
4. Vortex Shedding Flowmeter

- a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
 - b. Maximum Fluid Temperature: 800°F (427 °C).
 - c. Wetted Parts: Stainless Steel.
 - d. Housing: NEMA 4X.
 - e. Turndown: 25:1 minimum.
 - f. Accuracy: 0.5% calibrated span for liquids, 1% calibrated span for steam and gases.
 - g. Body: Wafer style or ANSI flanged to match piping specification.
- 5. Transit-Time Ultrasonic Flowmeter
 - a. Clamp-On transit-time ultrasonic flowmeter
 - b. Wide-Beam transducer technology
 - c. 4-20 mA transmitter proportional to flow or velocity.
 - d. Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.
- P. Thermal Energy Meters
 - 1. Matched RTD, solid state, or thermistor temperature sensors with a differential temperature accuracy of $\pm 0.15^{\circ}\text{F}$.
 - 2. Flow meter: See "Hydronic Flowmeters" section.
 - 3. Unit accuracy of $\pm 1\%$ factory calibrated, traceable to NIST with certification.
 - 4. NEMA 1 enclosure.
 - 5. Panel mounted display.
 - 6. UL listed.
 - 7. Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.
- Q. Current Switches.
 - 1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.
- R. Pressure Transducers.
 - 1. Transducers shall have linear output signal and field-adjustable zero and span.
 - 2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
 - 3. The water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducers shall have a two or three wire 2–10 Vdc or 4–20 mA output signal, suitable mounting provisions, and block and bleed valves.
 - 4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300psi.) Transducer shall have a two or three wire 2–10 Vdc or 4–20 mA output signal, suitable mounting provisions, and 5-valve manifold.
 - 5. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- S. Pressure-Electric (PE) Switches.
 - 1. Shall be metal or neoprene diaphragm actuated, operating pressure rated for 0–175 kPa (0–25 psig), with calibrated scale minimum setpoint range of 14–125 kPa (2–18 psig) minimum, UL listed.

2. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
 3. Switches shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
 4. Each pneumatic signal line to PE switches shall have permanent indicating gauge.
- T. Occupancy Sensors. Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.
- U. Local Control Panels.
1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
 2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
 3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.8 Wiring and Raceways

- A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

3.1 Examination

- A. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.
- B. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.2 Protection

- A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 Coordination

- A. Site
 - 1. Where the mechanical work will be installed near, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - 2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.
- B. Submittals. See Section 230900 Article 1.10 (Submittals).
- C. Test and Balance.
 - 1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 - 2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
 - 3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
 - 4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.
- D. Life Safety.
 - 1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in Section 230900 (Sequences of Operation).
 - 2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in Section 230900 (Sequences of Operation).
 - 3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.
- E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
 - 1. All communication media and equipment shall be provided as specified in Section 230900 Article 2.2 (Communication).
 - 2. Each supplier of a control's product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in Section 230900.

3. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.4 General Workmanship

- A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 Field Quality Control

- A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in Section 23 09 23 Article 1.8 (Codes and Standards).
- B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.
- C. Contractors shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.6 Existing Equipment

- A. Wiring. Interconnecting control wiring shall be removed and shall become the property of the contractor unless specifically noted or shown to be reused.
- B. Local Control Panels. Remove and deliver existing control panels to Owner.
- C. Repair. Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.
- D. Indicator Gauges. Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.
- E. Room Thermostats. Remove and deliver existing room thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.
- F. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Owner.
- G. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Owner.

- H. Damper Actuators, Linkages, and Appurtenances. Remove and deliver existing damper actuators, linkages, and appurtenances to Owner.
- I. Control Valves. Replace existing control valves with new. Deliver removed control valves to Owner.
- J. Control Compressed Air Systems. Replace existing control compressed air systems with new unless otherwise noted. Deliver removed systems to Owner.
- K. Existing System Operating Schedule. Existing mechanical system may be disabled during this work.
- L. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation.
- M. Install control panels where shown.
- N. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.
- O. Patch holes and finish to match existing walls.

3.7 Wiring

- A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.
- B. All NEC Class 1 (line voltage) wiring shall be UL listed in the approved raceway according to NEC and Division 26 requirements.
- C. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2's current limit.
- D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used if cables are UL listed for the intended application.
- E. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway at levels below 3 m (10ft).
- F. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- G. Do not install wiring in raceway containing tubing.
- H. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
- I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
- J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
- K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- L. The maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.
- M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
- N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

- O. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- P. Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- Q. Use color-coded conductors throughout with conductors of different colors.
- R. Control and status relays are to be in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- S. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).
- T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
- U. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.
- V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.
- W. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- X. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
- Y. Raceways must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

3.8 Communication Wiring

- A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.
- B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.
- D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each cable.
- F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lightning arrestor shall be installed according to the manufacturer's instructions.
- G. All runs of communication wiring shall be of unspliced length when that length is commercially available.
- H. All communication wiring shall be labeled to indicate origination and destination data.
- I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

- J. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
 - 1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
 - 2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
 - 3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated using repeaters.
 - 4. An MS/TP EIA-485 network shall have no T connections.

3.9 Installation of Sensors

- A. Install sensors in accordance with the manufacturer's recommendations.
- B. Mount sensors rigidly and adequately for the environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.
- D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.
- E. Sensors used in mixing plenums and hot and cold decks shall be of the average type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a capillary clip. Provide 3 m (1 ft) of sensing element for each 1 m²(1 ft²) of coil area.
- G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 3 m (10 ft) downstream.
- H. All pipe-mounted temperature sensors shall be installed in the wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
- I. Install outdoor air temperature sensors on the north wall, complete with sun shield at designated location.
- J. Differential Air Static Pressure.
 - 1. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
 - 2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
 - 3. Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 - 4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

- 6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.
- K. Smoke detectors, freeze stats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- L. Install humidity sensors for duct mounted humidifiers at least 3 m (10 ft) downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.10 Flow Switch Installation

- A. Use correct paddle for pipe diameter.
- B. Adjust flow switch according to manufacturer's instructions.

3.11 Actuators

- A. General. Mount and link control damper actuators according to manufacturer's instructions.
 - 1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
 - 2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 - 3. Provide all mounting hardware and linkages for actuator installation.
- B. Electric/Electronic
 - 1. Dampers: Actuators shall be directly mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer's recommendations.
 - 2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.12 Identification of Hardware and Wiring

- A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with control system address or termination number.
- B. All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.
- C. Permanently label or code each point of field terminal strips to show the instrument or item served.
- D. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.
- F. Identify room sensors related to terminal boxes or valves with nameplates.
- G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.
- H. Identifiers shall match recorded documents.

3.13 Controllers

- A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all the hardware points listed in Section 230900 (Sequences of Operation).

3.14 Programming

- A. Provide sufficient internal memory for the specified sequences of operation and trend logging.
- B. Software Programming.
 - 1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embedded into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
 - a. Text-based:
 - i. Must provide actions for all possible situations.
 - ii. Must be modular and structured.
 - iii. Must be commented.
 - b. Graphic-based:
 - i. Must provide actions for all possible situations.
 - ii. Must be documented.
 - c. Parameter-based:
 - i. Must provide actions for all possible situations.
 - ii. Must be documented.
- C. Operator Interface.
 - 1. Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all relevant input and output points for that equipment. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List in Section 230900.
 - 2. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.15 Control System Checkout and Testing

- A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
 2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
 4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
 5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
 7. Alarms and Interlocks:
 - a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.16 Control System Demonstration and Acceptance

- A. Demonstration.
1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
 2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
 3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
 4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and

sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.

5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "System Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:
 - a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
 - b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of shed able equipment outputs.
 - c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
 - d. Interface to the building fire alarm system.
 - e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
10. Any tests that fail to demonstrate the operation of the system shall be repeated later. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.17 Cleaning

- A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.18 Training

- A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.
- B. Training shall enable students to accomplish the following objectives.
 - 1. Day-to-day Operators:
 - a. Proficiently operate the system
 - b. Understand control system architecture and configuration.
 - c. Understand DDC system components.
 - d. Understand system operation, including DDC system control and optimizing routines (algorithms)
 - e. Operate the workstation and peripherals.
 - f. Log on and off the system.
 - g. Access graphics, point reports, and logs.
 - h. Adjust and change system set points, time schedules, and holiday schedules.
 - i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
 - j. Understand system drawings and Operation and Maintenance manual.
 - k. Understand the job layout and location of control components.
 - l. Access data from DDC controllers and ASCs
 - m. Operate portable operator's terminals.
 - 2. Advanced Operators:
 - a. Make and change graphics on the workstation.
 - b. Create, delete, and modify alarms, including annunciation and routing of these.
 - c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals.
 - d. Create, delete, and modify reports.
 - e. Add, remove, and modify system's physical points.
 - f. Create, modify, and delete programming.
 - g. Add panels when required.
 - h. Add operator interface stations.
 - i. Create, delete, and modify system displays, both graphical and others
 - j. Perform DDC system field checkout procedures.
 - k. Perform DDC controller unit operation and maintenance procedures.

- l. Perform workstation and peripheral operation and maintenance procedures.
- m. Perform DDC system diagnostic procedures.
- n. Configure hardware including PC boards, switches, communication, and I/O points.
- o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
- p. Adjust, calibrate, and replace system components.
- 3. System Managers/Administrators:
 - a. Maintain software and prepare backups.
 - b. Interface with job-specific, third-party operator software
 - c. Add new users and understand password security procedures.
- C. Organize the training into sessions or modules for the three levels of operators listed above. (Day-to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on the knowledge level required.
- D. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.
- E. The instructor(s) shall be factory-trained and experienced in presenting this material.
- F. Classroom training shall be done using a network of working controllers' representative of installed hardware.

3.19 Sequences of Operation

- F. Indoor Air Handling Units (Chilled Water Cool, Hydronic Heat : AHU-1)
 - a. The indoor air handler unit shall be controlled by its field installed, local control panel. The system shall be complete with access through local and remote terminal(s).
 - a. Whenever the indoor air handler unit fan is started, the outside air dampers shall open to their minimum positions.
 - b. Automatic air damper at outdoor louver shall open to minimum position when air handlers are running.
 - c. Whenever the cold deck temperature rises above the cold deck temperature setpoint, the 3-way control valve for chilled water system shall modulate open until unit is able to satisfy space temperature setpoint.
 - d. Whenever the hot deck temperature falls below the hot deck temperature setpoint, the 3-way control valve for hot water shall modulate open and engage the recirc pump on to satisfy the space temperature setpoint.
 - e. The unit's field controls shall maximize the use of free-cooling through the comparison of outdoor air and return air dry bulb temperature. When outdoor air temperature is less than the return air temperature and the economizer enable dry bulb setpoint then the outdoor air damper shall modulate open. When outdoor air dry bulb temperature is greater than return air dry bulb temperature, mechanical cooling shall be staged on to maintain space set-point, (72degF, adjustable).
 - f. Economizer Fault Detection and Diagnostics shall be implemented as an alarm to BAS system to verify the air-economizer is working properly.
 - g. The indoor air handler unit shall maintain a 70°F (adj.) space air temperature by modulating the hot deck and cold deck dampers associated with each individual space.
 - h. During unoccupied mode, set within the BAS system, the air handlers shall be disabled, but shall be enabled if a thermostat's setback setpoint is not satisfied.

- i. An override push button shall be located at each thermostat for any user to enable the system for 1-hour increments (adj.). After the 1-hour expires the system will return to unoccupied mode.
- j. On detection of smoke from the duct mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off and the outside air, return air and exhaust air dampers shall close, and an alarm shall be indicated on the local control system.

I. Unit Ventilators

- a. During occupied mode the following shall occur:
 - i. Unit ventilators shall open the hot water two-way control valves and cycle fans to maintain space temperature. Space temperature shall be monitored by a space temperature sensor.
 - ii. Similarly, unit ventilators shall open the chilled water two-way control valves and cycle fans to maintain space temperature. Space temperature shall be monitored by a space temperature sensor.
- b. During unoccupied mode, the UV shall be disabled until the thermostat's setback setpoint is reached. Once the setback setpoints are achieved, unit shall go into occupied mode to maintain setback setpoints (adj.)
- c. If the unit ventilator is in unoccupied mode and occupied mode is desired, it shall be overridden via an override switch on the thermostat.
- d. Anytime the unit is enabled during occupied mode, the OA damper shall be open to minimum position. The OA damper should be closed during unoccupied mode.

3.20 Start-Up and Checkout Procedures

- A. Start up, check out, and test all hardware and software and verify communication between all components.
 - 1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - 2. Verify that all analog and binary input/output points read properly.
 - 3. Verify alarms and interlocks.
 - 4. Verify operation of the integrated system

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Strainers.

B. Related Requirements:

1. Section 230523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
2. Section 230523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
3. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.

- B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. Anvil; an ASC Engineered Solution
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. Armstrong Fluid Technology
 - d. Bell & Gossett; a Xylem brand
 - e. Taco Comfort Solutions
 - f. Tour & Andersson; available through Victaulic Company
 - g. Tunstall Corporation
 - h. Victaulic Company
 - i. WATTS; A Watts Water Technologies Company
- 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
- 3. Ball: Brass or stainless steel.
- 4. Plug: Resin.
- 5. Seat: PTFE.
- 6. End Connections: Threaded or socket.
- 7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
- 8. Handle Style: Lever, with memory stop to retain set position.
- 9. CWP Rating: Minimum 125 psig
- 10. Maximum Operating Temperature: 250 deg F

B. Automatic Flow-Control Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. Anvil; an ASC Engineered Solution
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. Armstrong Fluid Technology
 - d. Bell & Gossett; a Xylem brand
 - e. Taco Comfort Solutions
 - f. Tour & Andersson; available through Victaulic Company
 - g. Tunstall Corporation
 - h. Victaulic Company
 - i. WATTS; A Watts Water Technologies Company
- 2. Body: Brass or ferrous metal.

3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: 175 psig
8. Maximum Operating Temperature: 200 deg F

2.2 STRAINERS

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. Anvil; an ASC Engineered Solution
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. Armstrong Fluid Technology
 - d. Bell & Gossett; a Xylem brand
 - e. Taco Comfort Solutions
 - f. Tour & Andersson; available through Victaulic Company
 - g. Tunstall Corporation
 - h. Victaulic Company
 - i. WATTS; A Watts Water Technologies Company
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: Stainless steel, 20 mesh strainer
5. CWP Rating: 125 psig

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine all piping specialties for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Examine threads on all devices for form and cleanliness.
- C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

- A. Install calibrated-orifice balancing valve at each branch connection to return main.
- B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.
- C. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 INSTALLATION OF HYDRONIC SPECIALTIES

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
 - 1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.
- C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- D. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Separately coupled, horizontally mounted, in-line centrifugal pumps.

1.2 DEFINITIONS

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. EPR: Ethylene propylene rubber.
- D. FKM: Fluoroelastomer polymer.
- E. HI: Hydraulic Institute.
- F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pump.
1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
 2. Indicate pump's operating point on curves.
- B. Shop Drawings: For each pump.
1. Show pump layout and connections.
 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in emergency, 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. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- 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.
 - 1. Component Importance Factor: 1.5.

2.2 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - 1. Armstrong Fluid Technology
 - 2. Bell & Gosset, Xylem
 - 3. Aurora Pump; Pentair Ltd.
 - 4. Flowserve Corporation
 - 5. ITT Corporation
 - 6. Mepco, LLC
 - 7. PACO Pumps; Grundfos Pumps Corporation, USA
 - 8. Scot Pump; a division of Ardox Corporation
 - 9. Taco Comfort Solutions
 - 10. Thrush Co. Inc.
- B. Source Limitations: Obtain pumps from single source from single manufacturer.
- C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- D. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, and threaded companion-flange connections.

2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: Carbon steel, with copper-alloy shaft sleeve]
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket.
 5. Pump Bearings: Permanently lubricated ball bearings
- E. Shaft Coupling: [Molded-rubber insert with interlocking spider] [Interlocking frame with interconnecting springs] capable of absorbing vibration.
- F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. Enclosure Type: OPD Open drip proof
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. 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.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. Single-speed motor.
 6. Provide integral pump motor variable-speed controller.
- G. Capacities and Characteristics: AS SCHEUDLED

2.3 ELECTRONICALLY COMMUTATED MOTOR (ECM)

- A. Provide pumps so they are specified or scheduled with ECM.
1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
 2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
 3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
 4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
 5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
 6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
- E. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.
 - 1. Provide with like-kind existing hangers and supports.

3.3 ALIGNMENT

- A. Engage a factory-authorized service representative to perform alignment service.
- B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.
- C. Comply with pump and coupling manufacturers' written instructions.

3.4 PIPING CONNECTIONS

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check, shutoff, and throttling valves on discharge side of pumps.
- E. Install suction diffuser and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element

before turnover of system to Owner.

- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.5 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ceiling-mounted ventilators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Capacities and Characteristics: SEE SCHEUDLES

2.2 CEILING-MOUNTED VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - 1. Carnes Company
 - 2. Greenheck Fan Corporation
 - 3. Loren Cook Company
- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.
- D. Back-draft damper: Integral.
- E. Grille: Plastic or Painted aluminum, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.
- F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- G. Accessories:
 - 1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - 3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 - 4. Motion Sensor: Motion detector with adjustable shutoff timer.
 - 5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless

- steel springs, and fusible link.
- 6. Isolation: Rubber-in-shear vibration isolators.
- 7. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors.
 - 1. 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.

2.4 SOURCE QUALITY CONTROL

- A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.
- B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.
- C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 STARTUP SERVICE:

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
 - 6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 7. Adjust belt tension.
 - 8. Adjust damper linkages for proper damper operation.
 - 9. Verify lubrication for bearings and other moving parts.
 - 10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 12. Shut unit down and reconnect automatic temperature-control operators.
 - 13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.

- C. Lubricate bearings.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties.
 - 3. Fans and components will be considered defective if they do not pass tests and inspections.
 - 4. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

SECTION 236423.13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. DDC: Direct digital control.
- D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.
- E. GFI: Ground fault interrupt.
- F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- G. I/O: Input/output.
- H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.
- J. SCCR: Short-circuit current rating.
- K. TEAO: Totally enclosed air over.
- L. TENV: Totally enclosed nonventilating.

1.3 ACTION SUBMITTALS

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

2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.
5. Refrigerant capacity of water chiller.
6. Oil capacity of water chiller.
7. Fluid capacity of evaporator.
8. Characteristics of safety relief valves.
9. Force and moment capacity of each piping connection.

B. Sustainable Design Submittals:

1. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
2. Product Data: For energy performance.

C. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
 - d. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
2. Each view to show screened background with the following:
 - a. Column grids, beams, columns, and concrete housekeeping pads.
 - b. Layout with walls, floors, and roofs, including each room name and number.
 - c. Equipment and products of other trades that are located in vicinity of chillers and part of final installation, such as plumbing systems.

B. Installation instructions.

C. Source quality-control reports.

D. Startup service reports.

- E. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 - 1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
 - 2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.
- B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
 - 1. Allowable Capacity Tolerance: Zero percent.
 - 2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
 - 3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.
- B. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.
- C. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- F. Comply with NFPA 70.
- G. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.
- H. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
 - 2. See drawings for equipment served by backup power systems.
 - 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- I. Outdoor Installations:
 - 1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.

2.2 AIR-COOLED, SCROLL WATER CHILLERS

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

1. Carrier Global Corporation
2. Daikin Applied
3. Trane (BOD)
4. YORK; brand of Johnson Controls International plc, Building Solutions North America

2.3 MANUFACTURED UNITS

- A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.
- B. Sound-reduction package shall have the following:
 1. Acoustic enclosure around compressors.
 2. Reduced-speed fans with acoustic treatment.
 3. Designed to reduce sound level without affecting performance.
- C. Security Package: Security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

2.4 CABINET

- A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
- B. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
- C. Casing: Galvanized steel.
- D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500 hour salt-spray test according to ASTM B117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

- A. Compressors:
 1. Description: Positive-displacement direct drive with hermetically sealed casing.
 2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
 3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
 4. Capacity Control:

- a. Digital or Variable speed compressors are an acceptable alternative to achieve capacity control.
- 5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.
 - a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
- 6. Vibration Isolation: Mount individual compressors on vibration isolators.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
- B. Compressor Motors:
 - 1. Hermetically sealed and cooled by refrigerant suction gas.
 - 2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
- C. Compressor Motor Controllers:
 - 1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

2.6 REFRIGERATION

- A. Refrigerant: R-454bB. Classified as Safety Group A1 according to ASHRAE 34.
- B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
- C. Refrigerant Circuit: Each circuit shall include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
- D. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
 - 1. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.
- E. Pressure Relief Device:
 - 1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.

3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

2.7 EVAPORATOR

- A. Brazed-plate or shell-and-tube design, as indicated.
- B. Brazed Plate:
 1. Direct-expansion, single-pass, brazed-plate design.
 2. Type 304 or 316 stainless-steel construction.
 3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
 4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
 5. Inlet Strainer: Factory-furnished, 20 or 40 mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.
- C. Flow Switch: Factory-furnished and -installed, thermal-type flow switch wired to chiller operating controls.
- D. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F

2.8 AIR-COOLED CONDENSER

- A. Coil(s) with integral subcooling on each circuit.
- B. Copper Tube with Plate Fin Coils:
 1. Construct coils of copper tubes mechanically bonded to aluminum copper fins.
 2. Coating: None
- C. Aluminum Microchannel Coils:
 1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 2. Single- or multiple-pass arrangement.
 3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.
- D. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- E. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
- F. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.
- G. Fan Guards: Removable steel safety guards with corrosion-resistant PVC coating.

2.9 INSULATION

- A. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C534/C534M, Type I for tubular materials and Type II for sheet materials.
1. Thickness: 1-1/2 inches
- B. Adhesive: As recommended by insulation manufacturer.
- C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
1. Apply adhesive to 100 percent of insulation contact surface.
 2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 3. Seal seams and joints to provide a vapor barrier.
 4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 5. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
 6. Field-Applied Insulation:
 - a. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
 - b. Manufacturer shall be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
 - c. Manufacturer's factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
 - d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.10 ELECTRICAL

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
- C. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.

- D. Wiring shall be numbered and color-coded to match wiring diagram.
- E. Factory wiring shall be located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch length of liquidtight or flexible metallic conduit.
- F. Field power interface shall be to wire lugs NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000 A.
- G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:
 - 1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
 - 2. NEMA KS 1, heavy-duty, nonfusible switch.
 - 3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- H. Each motor shall have overcurrent protection.
- I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
- J. Power Factor Correction: Capacitors to correct power factor to 0.90 at full load.
- K. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- L. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.
- M. Service Receptacle:
 - 1. Unit-mounted, 120-V GFI duplex receptacle.
 - 2. Power receptacle from chiller internal electrical power wiring.
- N. Indicate the following for water chiller electrical power supply:
 - 1. Current, phase to phase, for all three phases.
 - 2. Voltage, phase to phase and phase to neutral for all three phases.
 - 3. Three-phase real power (kilowatts).
 - 4. Three-phase reactive power (kilovolt amperes reactive).
 - 5. Power factor.
 - 6. Running log of total power versus time (kilowatt hours).
 - 7. Fault log, with time and date of each.

2.11 CONTROLS

- A. Factory installed and wired, and functionally tested at factory before shipment.

- B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
- D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:
 - 1. Date and time.
 - 2. Operating or alarm status.
 - 3. Operating hours.
 - 4. Outside-air temperature if required for chilled-water reset.
 - 5. Temperature and pressure of operating set points.
 - 6. Chilled-water entering and leaving temperatures.
 - 7. Refrigerant pressures in evaporator and condenser.
 - 8. Saturation temperature in evaporator and condenser.
 - 9. No cooling load condition.
 - 10. Elapsed time meter (compressor run status).
 - 11. Percent of maximum motor amperage.
 - 12. Current-limit set point.
 - 13. Number of compressor starts.
 - 14. Alarm history with retention of operational data before unit shutdown.
 - 15. Superheat.
- E. Control Functions:
 - 1. Manual or automatic startup and shutdown time schedule.
 - 2. Capacity control based on evaporator leaving-fluid temperature.
 - 3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
 - 4. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water temperature.
 - 5. Current limit and demand limit.
 - 6. External water chiller emergency stop.
- F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
 - 1. Low evaporator pressure or high condenser pressure.
 - 2. Low chilled-water temperature.
 - 3. Refrigerant high pressure.
 - 4. High or low oil pressure.
 - 5. High oil temperature.
 - 6. Loss of chilled-water flow.
 - 7. Control device failure.
- G. DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.
 - 1. Refer to section 230900 "Instrumentation and controls for HVAC"
 - 2. Communication Interface: Industry-accepted open-protocol communication

interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

- H. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquid-tight or flexible metallic conduit.

2.12 ACCESSORIES

- A. Refer to remarks on schedules drawing.

2.13 CAPACITIES AND CHARACTERISTICS (AS SCHEDULED)

2.14 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.

2.15 SOURCE QUALITY CONTROL

- A. Perform functional test of water chillers before shipping.
- B. Factory performance test water chillers, before shipping, according to AHRI 550/590.
 - 1. Test the following conditions:
 - a. Design conditions indicated.
 - b. AHRI 550/590 part-load points.
 - 2. Allow Owner access to place where water chillers are being tested. Notify Owner 14 days in advance of testing.
- C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
- D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
 - 1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

- A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.
- C. Install water chillers on support structure indicated.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Maintain clearances required by governing code.
- F. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
- G. Install separate devices furnished by manufacturer and not factory installed.
 - 1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

- A. Comply with requirements in Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to chillers, allow space for service and maintenance.
- C. Evaporator Fluid Connections:
 - 1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
 - 2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter,

- and drain connection with valve.
- 3. Make connections to water chiller with a union
- D. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 230900 "Instrumentation and Controls for HVAC"
- D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high.

3.6 STARTUP SERVICE

- A. Perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - 2. Verify that pumps are installed and functional.
 - 3. Verify that thermometers and gages are installed.

4. Operate water chiller for run-in period.
 5. Check bearing lubrication and oil levels.
 6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
 7. Verify proper motor rotation.
 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
 9. Verify and record performance of water chiller protection devices.
 10. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- E. Prepare a written startup report that records results of tests and inspections.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner.
1. Instructor shall be factory trained and certified.
 2. Provide not less than eight hours of training.
 3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 5. Obtain Owner sign-off that training is complete.
 6. Owner training shall be held at Project site.

END OF SECTION 236423.13

SECTION 238216.11 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

- ##### A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.4 CLOSEOUT SUBMITTALS

- ##### A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- ##### A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

- ##### B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.

- ##### C. Minimum Working-Pressure/Temperature Ratings: 200 psig / 300 deg F (149

- D. Hot-Water Coil Capacities and Characteristics: AS SCHEDULED

2.2 HYDRONIC AIR COILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Carrier Global Corporation
 2. Daikin
 3. Trane
 4. Or Approved Equal
- B. Source Limitations: Obtain hydronic coils from single source from single manufacturer.
- C. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.
- D. Tubes:
1. Material: Copper
 2. Nominal Diameter: Minimum 1/2 inch or 5/8 inch before expanding, selected to provide performance indicated.
 3. Nominal Wall Thickness: As required by performance, minimum [0.020 inch
 4. Return Bends: 180-degree bends; material, wall thickness, and nominal diameter to match tubes.
- E. Fins:
1. Type: Plate.
 2. Materials:
 - a. Aluminum: 0.0060 inch
 3. Spacing: Maximum 12 fins per inch
 4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 5. Configuration: Flat-face fins
 6. Fin and Tube Joint: silver brazed.
- F. Headers:
1. Material: Copper
 2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
 3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
 4. Drains: Include low point of supply header with a NPS 1/2 drain connection.
 5. Vents: Include high point of return header with a NPS 1/2 vent connection.
 6. Supply and Return Connections: Copper pipe; threaded or flanged, same end of

- coil.
- 7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.
- G. Casings and Tube Sheets:
 - 1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
 - 2. Materials:
 - a. Stainless steel, Type 304 No. 2D finish, ASTM A240/A240M.
 - b. Galvanized steel, ASTM A653/A653M, G90 coating.
 - c. Copper, ASTM B152/B152M.
- H. End Tube Sheets:
 - 1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2. Flange face minimum of 1-1/2 inches
 - 3. Thickness: Minimum of 16 gauge thick.
- I. Intermediate Tube Sheets:
 - 1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - 3. Flange face minimum of 1/2 inch .
 - 4. Thickness: Minimum of 16 gauge thick.
- J. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
- K. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.
- L. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - 1. Manufacturer name, address, telephone number, and website address.
 - 2. Manufacturer model number.
 - 3. Serial number.
 - 4. Manufacturing date.
 - 5. Coil identification (indicated on Drawings).
 - 6. Coil fin length.
 - 7. Coil fin height.
 - 8. Coil weight with fluid/without fluid.
 - 9. Coil casing material and thickness.
 - 10. Coil fin material and thickness.
 - 11. Coil tube material and thickness.
 - 12. Coil header material and thickness.

2.3 MATERIALS

- A. Aluminum: ASTM B209
- B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.
- C. Copper Sheet: ASTM B152.
- D. 90/10 Cupronickel Alloy: ASTM B122/ASTM B122M.
- E. Steel:
 - 1. Pipe Connections: ASTM A53/A53M.

2.4 SOURCE QUALITY CONTROL

- A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than 300-psig internal pressure.
- B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install galvanized drain pan under each cooling coil.
 - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 - 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 - 3. Extend drain pan upstream and downstream from coil face.
 - 4. Extend drain pan under coil headers and exposed supply piping.

- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
- E. Straighten bent fins on air coils.
- F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION 238216.11

SECTION 238223 - UNIT VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Unit ventilators.
 - a. Hydronic heating coil.
 - b. Hydronic cooling coil.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product

1. Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail anchorages and attachments to structure and to supported equipment.
4. Include diagrams for power, signal, and control wiring.

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

D. Samples for Verification: For each type of unit ventilator and auxiliary shelves and cabinets indicated.

1.3 INFORMATIONAL SUBMITTALS

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

1. Perimeter moldings.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For unit ventilators to include in emergency,

operation, and maintenance manuals.

1.5 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. Unit Ventilator Filters: Furnish 2 spare filter(s) for each filter installed.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 COORDINATION

- A. Coordinate size and location of wall sleeves for outdoor-air intake.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

- 1. Failures include, but are not limited to, the following:

- a. Compressor failure.
 - b. Condenser coil leak.

- 2. Warranty Period: Four years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- 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. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

2.2 UNIT VENTILATORS

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

UNIT VENTILATORS

238223 - 2
146.203

the following

1. Carrier Global Corporation
2. Daikin Applied
3. Trane

B. Manufactured Units:

1. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in draw through configuration, and hydronic cooling coil.
2. Unit Ventilator Coil Configurations: Row split.
 - a. Number of Heating Coils: One with two-pipe system.
 - b. Number of Cooling Coils: One with two pipe system.

C. Cabinets:

1. Insulation: Minimum 1/2-inchthick, matte-finish, closed-cell foam complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."
 - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner, formed as required by ASHRAE 62.1.Drain pans shall be removable.
4. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors.
 - a. Steel components exposed to moisture shall be hot-dip galvanized after fabrication
5. Cabinet Finish:
 - a. Coordinate with Architect.
6. Return-Air Inlet: Front toe space.
7. End Panels: Matching material and finish of unit ventilator.

D. Coils:

1. Test and rate unit ventilator coils according to ASHRAE 33.
2. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch , rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F . Include manual air vent and drain valve.

E. Indoor Fan:

1. Fan and Motor Board: Removable.
 - a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - b. Fan Shaft and Bearings: Hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
 - c. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230500 "Common Work Results for HVAC."
 - d. Wiring Termination: Connect motor to chassis wiring with plug connection.

F. Dampers:

1. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric actuator.
2. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric actuator.
3. Comply with ASHRAE/IES 90.1.

G. Accessories:

1. Filters:
 - a. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
 - b. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
 - c. Material:
 - 1) Pleated cotton-polyester media, MERV 8

H. Factory Hydronic Piping Package:

1. Piping: ASTM B88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Crossover piping, NPS 1-1/2 with shutoff valves.
2. Control Valves: Electric actuators compatible with terminal controller and building controls.
 - a. Two- way, two-position control valve for chilled and Hot water coil.
3. Isolation Valves, Strainers, Unions, and Balance Valves:
 - a. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and

galvanized-steel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.

I. Basic Unit Controls:

1. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
2. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.3 METAL SHELVES AND CABINETS

A. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:

1. Closed Shelving with Reinforced Shelves:
 - a. Radiation enclosure and aluminum bar grille with finish to match unit ventilator grille.
 - b. Through-piping enclosure with solid top.
 - c. Two sliding doors with key-operated locks.
2. Utility compartment with access panel with key-operated lock.
3. Wall and corner filler sections, and end panels finished to match shelving.

B. Painted Finish: Coordinate with Architect

2.4 CAPACITIES AND CHARACTERISTICS: AS SCHEDULED

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive unit ventilators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF UNIT VENTILATORS

- A. Install unit ventilators to comply with NFPA 90A.

- B. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

END OF SECTION 238223

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- D. Conductor Insulation:
 - 1. Type THHN and Type THWN-2: Comply with UL 83.
 - 2. Type XHHW-2: Comply with UL 44.

2.2 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Material: Copper.
 - 2. Type: One hole with standard barrels.
 - 3. Termination: Crimp.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 - 2. Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
 - 1. Copper, Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 - 2. Copper, Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.
- C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- B. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- C. Exposed Branch Circuits: Type THHN/THWN-2, single conductors in raceway.
- D. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
 - 1. Instructions for periodic testing and inspection of grounding features at ground rings based on NFPA 70B.
 - a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- 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. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.3 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Conduit Hubs: Mechanical type, terminal with threaded hub.
- G. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- H. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

- I. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- J. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- K. Straps: Solid copper, copper lugs. Rated for 600 A.
- L. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.
- M. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).
- B. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.

2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.
 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural

drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

- b. Perform tests by fall-of-potential method according to IEEE 81.
- 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Substations and Pad-Mounted Equipment: 5 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.

2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

- A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 1. Flame Rating: Class 1.
 2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 2. Material for Channel, Fittings, and Accessories: Galvanized steel.
 3. Channel Width: Selected for applicable load criteria.
 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).
6. Toggle Bolts: Stainless-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA 1.
 2. NECA 101
 3. NECA 102.
 4. NECA 105.
 5. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with single-bolt conduit clamps.

- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To New Concrete: Bolt to concrete inserts.
 - 2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 3. To Existing Concrete: Expansion anchor fasteners.
 - 4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 5. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

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

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and features in paths of conduit groups with common supports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with ANSI C80.1 and UL 6.
3. ARC: Comply with ANSI C80.5 and UL 6A.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. FMC: Comply with UL 1; aluminum.

7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings: Comply with NEMA FB 1 and UL 514B.

1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
4. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew.
5. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. ENT: Comply with NEMA TC 13 and UL 1653.
2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
3. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:

1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
3. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- J. Gangable boxes are prohibited.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Nonmetallic Enclosures: Plastic.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated.

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: GRC.
6. Boxes and Enclosures: NEMA 250, Type 1.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. .
3. EMT: Use setscrew, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).
- H. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- I. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- J. Do not fasten conduits onto the bottom side of a metal deck roof.
- K. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- L. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- M. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- N. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- O. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- P. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- Q. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange raceways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Engineer for each specific location.
 - 5. Change from ENT to GRC before rising above floor.
- R. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

- S. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- T. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- V. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- W. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.
- X. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Conduit extending from interior to exterior of building.
 - 4. Conduit extending into pressurized duct and equipment.
 - 5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - 6. Where otherwise required by NFPA 70.
- Y. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m).
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.

- c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F (0.06 mm per meter of length of straight run per degree C) of temperature change for PVC conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
 - Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 36 inches (915 mm) of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations subject to severe physical damage.
 - 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
 - AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
 - BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
 - CC. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
 - DD. Locate boxes so that cover or plate will not span different building finishes.
 - EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
 - FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- 3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- 3.3 FIRESTOPPING
- A. Install firestopping at penetrations of fire-rated floor and wall assemblies.

3.4 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

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. Round sleeves.
 - 2. Rectangular sleeves.
 - 3. Sleeve seal systems.
 - 4. Grout.
 - 5. Pourable sealants.
 - 6. Foam sealants.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

- A. Wall Sleeves, Steel:
 - 1. Description: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.
- B. Pipe Sleeves, PVC:
 - 1. Description: ASTM D1785, Schedule 40.
- C. Sheet Metal Sleeves, Galvanized Steel, Round:
 - 1. Description: Galvanized-steel sheet; thickness not less than 0.0239-inch (0.6-mm); round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 RECTANGULAR SLEEVES

A. Sheet Metal Sleeves, Galvanized Steel, Rectangular:

1. Description:

- a. Material: Galvanized sheet steel.
- b. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness must be 0.052 inch (1.3 mm).
 - 2) For sleeve cross-section rectangle perimeter not less than 50 inches (1270 mm) or with one or more sides larger than 16 inches (400 mm), thickness must be 0.138 inch (3.5 mm).

2.3 SLEEVE SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.5 POURABLE SEALANTS

A. Description: Single-component, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2.6 FOAM SEALANTS

- A. Description: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless sleeve seal system is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- C. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for wall assemblies.
- D. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seal systems. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS

- A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.
- B. Install conduits and cable with no crossings within the sleeve.
- C. Fill opening around conduits and cables with expanding foam without leaving voids.
- D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE SEAL SYSTEMS

- A. Install sleeve seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL 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. Color and legend requirements for raceways, conductors, and warning labels and signs.
 - 2. Labels.
 - 3. Bands and tubes.
 - 4. Tapes and stencils.
 - 5. Tags.
 - 6. Signs.
 - 7. Cable ties.
 - 8. Paint for identification.
 - 9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase-and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service conductors.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
3. Colors for 240-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
4. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
5. Color for Neutral: White.
6. Color for Equipment Grounds: Bare copper.
7. Colors for Isolated Grounds: Green two or more yellow stripes.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

- A. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
 - 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 - 2. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameter and that stay in place by gripping action.

2.5 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

2.6 TAGS

- A. Write-on Tags:
 - 1. Polyester Tags: 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

- A. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Engraved legend.
 - 2. Thickness:
 - a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
 - b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
 - c. Engraved legend with black letters on white face>.
 - d. Self-adhesive.

- e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black, except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.
- H. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- I. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "POWER."
- M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- N. Self-Adhesive Wraparound Labels: Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
- O. Self-Adhesive Labels:
 - 1. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
- P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- Q. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

R. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using [general-purpose] [UV-stabilized] [plenum-rated] cable ties.

S. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

T. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30A and 120V to Ground: Identify with self-adhesive raceway.
 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
 1. "POWER."
- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes use self-adhesive wraparound labels to identify the phase.
 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

- F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes use self-adhesive wraparound labels with the conductor or cable designation, origin, and destination.
- G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive wraparound labels with the conductor designation.
- H. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive equipment labels.
 - 1. Apply to exterior of door, cover, or other access.
 - 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Controls with external control power connections.
- J. Operating Instruction Signs: Self-adhesive labels.
- K. Equipment Identification Labels:
 - 1. Indoor Equipment: Self-adhesive label.
 - 2. Outdoor Equipment: Laminated acrylic or melamine sign.

END OF SECTION 260553

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Switchbox-mounted occupancy and vacancy sensors

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
 - 4. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V, and 800-W incandescent.
- B. Wall-Switch Sensor:
 - 1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
 - 2. Sensing Technology: Dual-technology.
 - 3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
 - 4. Capable of controlling load in three-way application.
 - 5. Voltage: Match the circuit voltage.
 - 6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 - 7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 - 8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
 - 9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
 - 10. Color: White.
 - 11. Faceplate: Color matched to switch.

2.2 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.

- B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

- A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).
- B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's written instructions.
- C. Size conductors in accordance with lighting control device manufacturer's written instructions unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

- A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Lighting control devices will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two> visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-grade duplex straight-blade receptacles.
2. GFCI receptacles, 125 V, 20 A.
3. Toggle switches, 120/277 V, 20 A.
4. Wall plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1.
- E. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
- F. Wall Plate Color: For plastic covers, match device color.
- G. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
2. Standard Features:
 - a. Device Color: Match existing.
 - b. Configuration:
 - 1) General-duty, NEMA 5-20R.
3. Accessories:
 - a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: Non-feed through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Type: Non-feed through.
4. Standards: Comply with UL 498 and UL 943 Class A.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A:

1. Standards: Comply with UL 20 and FS W-S-896.

2.5 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
 - 3. Material for Unfinished Spaces: Galvanized steel.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 2. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 3. Install wiring devices after all wall preparation, including painting, is complete.
- C. Device Installation:
 - 1. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 - 2. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
- D. Receptacle Orientation:
 - 1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
 - 2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
- E. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

- F. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- G. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- B. Tests for Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Enclosed switches.

1.2 ACTION SUBMITTALS

- ##### A. Product Data:
- For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 3. Current-limitation curves for fuses with current-limiting characteristics.
 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
 5. Coordination charts and tables and related data.

1.3 FIELD CONDITIONS

- ##### A.
- Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 FUSES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Bussmann, an Eaton business
 - 2. Littelfuse, Inc.
 - 3. Mersen USA
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 - 1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
- B. 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.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be

- applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class RK1, time delay.
2. Motor Branch Circuits: Class RK1, time delay.
3. Other Branch Circuits: Class RK1, time delay.
4. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Nonfusible switches.
 - 2. Enclosures.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For enclosed switches and circuit breakers.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Include wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.2 NONFUSIBLE SWITCHES

- A. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).
- C. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock

mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.2 INSTALLATION

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Indicate method of providing temporary electric service.
 - 3. Do not proceed with interruption of electric service without Owner's written permission.
 - 4. Comply with NFPA 70E.
- B. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Comply with NFPA 70 and NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

- B. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, grounding, and clearances.
- c. Verify that the unit is clean.
- d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
- e. Verify that fuse sizes and types match the Specifications and Drawings.
- f. Verify that each fuse has adequate mechanical support and contact integrity.
- g. Inspect bolted electrical connections for high resistance using one of the two following methods:

- 1) Use a low-resistance ohmmeter.

- a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

- a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and clearances.
- d. Verify that the unit is clean.
- e. Operate the circuit breaker to ensure smooth operation.
- f. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- g. Inspect operating mechanism, contacts, and chutes in unsealed units.
- h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of

manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

- c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
 - e. Determine the following by primary current injection:
 - 1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.
 - f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
 - g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
 - h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
 - i. Verify operation of charging mechanism. Investigate units that do not function as designed.
- 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- 1. Test procedures used.

2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262816

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the following types of LED luminaires:
 - 1. Linear.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - 2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of luminaire.
- B. Product test reports.
- C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.

- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.6 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Ambient Temperature: 5 to 104 deg F (Minus 15 to plus 40 deg C)
 - 1. Relative Humidity: Zero to 95 percent.
- B. Altitude: Sea level to 1000 feet (300 m).

2.2 LUMINAIRE REQUIREMENTS

- 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. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI.
- C. Recessed luminaires shall comply with NEMA LE 4.

2.3 LINEAR

- A. Lamp:
 - 1. Minimum allowable efficacy of 80 lm/W.
 - 2. CRI of minimum 80. CCT of 4000 K.
 - 3. Rated lamp life of 50,000 hours to L70.
 - 4. Internal driver.
 - 5. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
- B. Housings:

1. Extruded-aluminum housing and heat sink.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- D. Diffusers and Globes:
 1. Prismatic acrylic.
 2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 3. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
- E. With integral mounting provisions.
- F. Standards:
 1. ENERGY STAR certified.
 2. RoHS compliant.

2.4 MATERIALS

- A. Metal Parts:
 1. Free of burrs and sharp corners and edges.
 2. Sheet metal components shall be steel unless otherwise indicated.
 3. Form and support to prevent warping and sagging.
- B. Steel:
 1. ASTM A36/A36M for carbon structural steel.
 2. ASTM A568/A568M for sheet steel.
- C. Stainless Steel:
 1. 1. Manufacturer's standard grade.
 2. 2. Manufacturer's standard type, ASTM A240/240M.
- D. Galvanized Steel: ASTM A653/A653M.
- E. Aluminum: ASTM B209.

2.5 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.2 IDENTIFICATION

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

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 265119

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Exit signs.
 - 2. Luminaire supports.

1.2 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with integral or remote emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support, arranged by designation.
- B. Shop Drawings: For nonstandard or custom luminaires.
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, coordinated with each other, using input from installers of the items involved:
- B. Product Certificates: For each type of luminaire.
- C. Sample Warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two year(s) from date of Substantial Completion.
- B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 EXIT SIGNS

- A. Internally Lighted Signs:
 - 1. Operating at nominal voltage of 120 V ac.
 - 2. Lamps for AC Operation: Fluorescent, two for each fixture; 20,000 hours of rated lamp life.
 - 3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
 - 4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit (90 minutes).

2.2 MATERIALS

- A. Metal Parts:
 - 1. Free of burrs and sharp corners and edges.
 - 2. Sheet metal components shall be steel unless otherwise indicated.
 - 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access:
 - 1. Smooth operating, free of light leakage under operating conditions.
 - 2. Designed to permit relamping without use of tools.
 - 3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Diffusers and Globes:
 - 1. Prismatic acrylic.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
 - 3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

- 4. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
- D. Housings:
 - 1. Extruded aluminum.
- E. Conduit: Electrical metallic tubing, minimum 3/4 inch (21 mm) in diameter.

2.3 METAL FINISHES

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.4 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position when testing emergency power unit.
 - 3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of fixture weight.
- E. Wall-Mounted Luminaire Support:
 - 1. Attached to a minimum 20-gage backing plate attached to wall structural members.
 - 2. Do not attach fixtures directly to gypsum board.
- F. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 265213

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding connectors.
3. Grounding and bonding busbars.
4. Labeling.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 DEFINITIONS

- A. BBC: Backbone bonding conductor for telecommunications.
- B. PBB: Primary bonding busbar for telecommunications.
- C. SBB: Secondary bonding busbar for telecommunications.
- D. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
1. BBC, PBB, SBBs, and routing of their bonding conductors.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as a designer RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- 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. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-D.

2.2 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Panduit Corp.
 2. TE Connectivity Ltd.
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green, insulated for 600 V, and complying with UL 83.
 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 2. Cable Tray Equipment Grounding Wire: No. 8 AWG.
- D. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - 2. Chatsworth Products, Inc.
 - 3. Harger Lightning & Grounding; business of Harger, Inc.
 - 4. Panduit Corp.
- B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
 - 1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.

2.4 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Chatsworth Products, Inc.
 - 2. Harger Lightning & Grounding; business of Harger, Inc.
 - 3. Panduit Corp.
- B. PBB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as PBB and shall comply with TIA-607-D.
 - 1. Predrilling shall be with holes for use with lugs specified in this Section.
 - 2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 - 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. SBB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-D.
 - 1. Predrilling shall be with holes for use with lugs specified in this Section.
 - 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.

3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

2.5 IDENTIFICATION

- A. Comply with requirements for identification products in Section 271700 "Testing and Identification".

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BBC connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BBC only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-D.

3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 1. The bonding conductors between the SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 2. The bonding conductors between the PBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- B. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 2. Connections to Structural Steel: Welded connectors.

C. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch intervals.
4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a SBB.

3.4 GROUNDING ELECTRODE SYSTEM

- A. The BBC between the PBB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.

3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.

3.6 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 1. Use crimping tool and the die specific to the connector.
 2. Pretwist the conductor.
 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the PBB with insulated bonding conductor.
- E. Interconnections: Interconnect all SBBs with the PBB with the telecommunications backbone conductor. If more than one PBB is installed, interconnect PBBs using the grounding equalizer

conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.

- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
- G. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each SBB to the ground bar of the panelboard.
- H. Shielded Cable: Bond the shield of shielded cable to the SBB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.
- I. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

3.7 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 - 1. Label PBB(s) with "fs-PBB," where "fs" is the telecommunications space identifier for the space containing the PBB.
 - 2. Label SBB(s) with "fs-SBB," where "fs" is the telecommunications space identifier for the space containing the SBB.
 - 3. Label the BBC and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a PBB and a SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

- a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
- 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- C. Excessive Ground Resistance: If resistance to ground at the BBC exceeds 5ohms, notify Architect promptly and include recommendations to reduce ground resistance.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 270526

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SECTION 270528 - COMMUNICATIONS SYSTEMS PATHWAYS

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 minimum requirements for the following as shown on the T-Series drawings:
 - 1. Interior Horizontal Cabling Communication Pathways
 - 2. Interior Backbone Cabling Communication Pathways
- B. Minimum composition requirements and installation methods for the following pathways:
 - 1. Conduit
 - 2. Innerduct
 - 3. Sleeves
 - 4. Fire Rated Pathways
 - 5. Cable tray/J Hooks
 - 6. Cable hangers
 - 7. Metallic Surface Raceway
 - 8. Floor Boxes
 - 9. Outlet Boxes

1.3 Related Requirements

- A. 27 15 00 Horizontal Cabling
- B. 27 17 00 Testing and Identification

1.4 QUALITY ASSURANCE

- A. All pathways and associated 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's Representative. 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, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the applicable requirements of:

1. National Electric Code (NFPA 70) including the following Articles:
 - a) Cable Trays
 - b) 331 - Electrical Nonmetallic tubing
 - c) 348 - Electrical metallic tubing
 - d) 349 - Flexible metallic tubing
 - e) 350 - Flexible metal conduit
 - f) 351 - Liquid-Tight Flexible metal conduit and Liquid-Tight flexible nonmetallic conduit.
 - g) 352A - Surface Metal Raceways
 - h) 352B - Surface Nonmetallic raceways
 - i) 353 - Multi-outlet Assembly
 - j) 354 - Under-floor raceways
 - k) 362 - Metal Wireways and nonmetallic Wireways
 - l) 370 - Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings
 - m) 645 - Information Technology Equipment
 - n) 770 - Optical Fiber Cables and Raceways
 - o) 800 - Communications Circuits
2. National Electric Code (NFPA-71) Central Signaling Systems
3. National Electric Code (NFPA-72) National Fire Alarm Code
4. National Electric Code (NFPA-75) Protection of Electronic and Computer Data Processing Equipment
5. National Electric Code (NFPA-780) Lightning Protection Code
6. National Electric Code (NFPA-101) Life Safety Code
7. The following American National Standards Institute (ANSI) standards:
 - a) ANSI-C80.3 Specification for Electrical Metallic Tubing, Zinc-coated
8. The following Telecommunication Industry Association (TIA) standards.
 - a) ANSI/TIA/EIA - 568-C Commercial Building Telecommunications Cabling Standard
 - b) ANSI/TIA/EIA - 569-A Commercial Building Standard for Telecommunications Pathway and Spaces
 - c) EIA/TIA-606-A Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
 - d) EIA/TIA-607 Commercial Building Grounding and Bonding requirements for Telecommunications
9. The following BICSI guidelines
 - a) BICSI Telecommunications Distribution Design Manual
 - b) BICSI Customer Owned Outside Plant Design Manual
 - c) BICSI Telecommunications Cabling Installation Manual
10. The following UL Standards:

- a) UL 1, - Flexible Metal Electrical Conduit
- b) UL 3, - Flexible Nonmetallic Tubing for Electric Wiring
- c) UL 5, - Surface Metal Electrical Raceways and Fittings
- d) UL 360, - Liquid-Tight Flexible Steel Conduit, Electrical
- e) UL 514B, - Fittings for Conduit and Outlet Boxes.
- f) UL 797, - Electrical Metallic Tubing
- g) UL 870, - Electrical Wireways, Auxiliary Gutters and Associated Fittings

1.5 SUBMITTALS

- A. Provide product data for products specified.

PART 2 PRODUCTS

2.1 CONDUIT

- A. Rigid Galvanized Steel Conduit

- 1. Shall be hot-dipped galvanized steel, including threads.

- B. Electrical Metallic Tubing (EMT)

- 2. Shall be electro-galvanized steel.

- C. Fittings

- 1. Rigid galvanized steel fittings shall be fully threaded and shall be of the same material as the respective raceway system.
- 2. Fittings for electrical metallic tubing shall be single screw indenter fittings for conduits up to 2" and double screw indenter fittings for conduits 2" and larger.
- 3. Connectors shall have insulated throat up to and including 1" size. For sizes 1-1/4" and larger, provide plastic insulating bushing.
- 4. Die-cast or pressure cast fittings are not permitted.
- 5. Provide conduit body types, shapes and sizes as required to suit application and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.

- D. Expansion Fittings

- 1. Provide expansion fittings with external grounding straps at building expansion joints.
- 2. Galvanized steel expansion joints for RGS or EMT conduit
- 3. Provide a minimum of 4" movement in either direction.
- 4. Weatherproof for outdoor applications.
- 5. At expansion joints in concrete pours, provide Deflection/Expansion fittings capable of movement of 3/4" in all directions from the normal.

E. Waterproofing Seals

1. Provide watertight expanding link-type seals for installation between the conduit and the sleeve or core drilled hole.
2. Design Make: Link Seal, or approved equal

F. Pull and Junction Boxes

1. Shall be constructed of not less than 14 gauge galvanized steel with trim for flush or surface mounting in accordance with the location to be installed. Boxes installed in damp or wet locations shall be of raintight construction with gasketed cover and threaded conduit hubs. Size pullboxes according to ANSI/TIA/EIA-569-B. Boxes shall be NEMA approved for the environmental condition of the location where they will be installed.

2.2 SLEEVES

- A. All sleeves shall have a minimum 1-hour UL listed fire rated assembly installed regardless if the wall or floor is not fire rated or has a rating of lesser value. If the wall or floor has a fire rating greater than 1 hours the sleeve shall have an equal rating in all cases.
- B. Rated assemblies:
1. STI –EZ Path
 2. Hilt
 3. 3M
- C. Non-rated walls: minimum 1” EMT conduit with bushings installed on both ends with fire stop system installed.

2.3 GROUNDING BUSHINGS

- A. Shall be provided for all Sleeves and Conduits.
1. Shall facilitate a bonding path for all Sleeves and conduits back to Telecommunication Ground Bar in each TR.
 2. Bushing shall provide protection for cables from damage.
 3. Design Make Thomas & Betts or approved equal.
 - a) Thomas & Betts 4” BG210
 - b) Thomas & Betts 3” BG208
 - c) Thomas & Betts 2” BG206
 - d) Thomas & Betts 1” BG203

2.4 CABLE TRAY

- A. Provide complete basket-style cable tray system and necessary accessories.
- B. Provide sizes as shown on plans.
- C. Cable tray system shall meet all local governing codes.
- D. Basket-style trays shall be high mechanical strength steel wire welded and include all fittings and accessories.
 - 1. Carbon steel ASTM A510 Grade 1008.
 - 2. 5.9mm wire diameter.
 - 3. Black Powder coated, ASTM D 3451.
 - 4. Electrocoat plating ASTM B 633.
 - 5. Loading Data:
- E. Provide safety loading in accordance with NEMA standards.
- F. Fittings shall include (but not be limited to):
 - 1. Splice connectors
 - 2. Quick tee and quick cross connectors
 - 3. Horizontal and vertical pivot connectors
 - 4. Universal stiffeners
 - 5. Seismic restraints and bracing
 - 6. Cable drop outs
 - 7. Grounding straps
- G. Utilize minimum 3/8" ATR trapeze supports.
- H. Design make: Legrand Cablofil (CF54/300) or approved equal.

2.5 CABLE HANGERS/ J HOOKS

- A. Provide prefabricated, zinc coated, carbon steel hangers designed specifically for UTP and Optical Fiber cable installations.
- B. Hangers shall have open top, rolled edges and a 1 5/16" minimum diameter loop.
- C. Hangers shall have a cable retainer.
- D. Provide beam clamps, rod fasteners, flange clips and brackets as job conditions require.
- E. Design Make: BLine BCH series, nVent Caddy CatHP or approved equal

2.6 CABLE MANAGEMENT

- A. Hook and Loop ties
 - 1. Design Make: Siemon, Legrand

2.7 SURFACE RACEWAY

- A. System: Provide surface raceway systems for branch circuit and data network voice, video and other low-voltage wiring. Surface raceway system shall consist of raceway bases, covers, appropriate fittings and device mounting plates necessary for a complete installation.
- B. Configuration: Raceways shall be two-piece design with base and snap-on cover. Where required base shall be dividable with a fixed barrier for up to 4 compartments. Raceway shall be available in widths of 3/4 inch to 10 inch and depths of 17/32 inch to 5 inch. Provide raceways from a company which can provide custom sizes if required. Raceway covers shall be available in tamper-resistant form with screws on access plates and covers of fittings, but not on standard cover lengths.
- C. Fittings: Fittings shall include flat, internal and external elbows, couplings for joining raceway sections, wire clips, blank end fittings, device mounting brackets and plates as applicable, and boxes. Where required, provide tamper-resistant form, dividable with barriers and matching the size of the accompanying raceway base. Provide full capacity corner elbows, entrance end fittings and tee fittings to maintain a controlled 2 inch cable bend radius, meeting the specification for Fiber Optic and UTP cabling and exceeding the TIA/EIA-569-A requirements for communications pathways.
- D. Device Brackets, Boxes and Plates: Provide in sizes to match the raceway width and with mounting holes located to ensure proper mounting of devices in up to 4 compartments. Device plates shall be available in any length from 6 inch to 60 inch, with cutouts to accommodate various combinations of power and communications devices in up to 4 compartments. Provide 6 inch and 12 inch long device plates with a flange to overlap the joint of adjacent cover as applicable. Boxes shall be 2.75" extra deep single or double gang to accommodate the bend radius and number of cables.
- E. Communications Devices and Accessories: Raceway shall accommodate a complete line of connectivity outlets and modular inserts for UTP (including Category 5, 5e, 6) STP (150 ohm), fiber optic, coaxial, and other cabling types with matching faceplates and bezels to facilitate mounting.
- F. Design Make(metallic): Wiremold or approved equal
 - 1. SR2 Wiremold 2400 Series
 - 2. SR4 Wiremold 4000 Series
 - 3. SR6 Wiremold 6000 Series

2.8 OUTLET BOXES

- A. Outlet Boxes and Covers
 - 1. Shall be galvanized steel, not less than 2 3/4" deep X 4 11/16" square with knockouts.
 - 2. Outlet boxes exposed to moisture, exterior, wet or damp locations shall be cadmium cast alloy complete with threaded hubs and gasketed screw fastened covers.
 - 3. Boxes shall be approved for the environmental condition of the location where they will be installed.

4. The box shall be fitted with either a single or double-gang “mud ring” to suit the outlet configuration required.
5. A pull string shall be installed from end to end in the conduit
6. Acceptable manufacturers:
 - a) Steel City
 - b) Raco
 - c) Appleton
 - d) Crouse Hinds

2.9 SUPPORTING DEVICES

- A. Supports, support hardware and fasteners shall be protected with zinc coating or treatment of equivalent corrosion resistance using approved alternative treatment, finish or inherent material characteristic. Products used for outdoor applications shall be hot dipped galvanized.
- B. Provide clevis hangers, riser clamps, conduit straps, threaded c clamps with retainers, ceiling trapeze hangers, wall brackets and spring steel clamps as applicable.
- C. 14 gauge U-Channel systems with 9/16 inch diameter holes at a minimum of 1 7/8 inches on center in the top surface. Provide fittings and accessories that match and mate channel.
- D. Provide carbon steel or wedge or sleeve type expansion anchors, steel springhead toggle bolts and heat-treated steel power driven threaded stud fastening equipment as required by construction types.
- E. Provided field fabricated supporting devices such as angles, channels, pipe supports, etc. All fabricated supports shall be of metal construction as called for in 2.1.T

2.10 INNERDUCT

- A. Within Duct Bank: Fabric inner duct, 3” with 3 cells per unit, capable to hold cable to 1.05”, Shall be rated for underground duct use.
- B. Within buildings: non-metallic, flexible, PVC riser rated, orange in color, ribbed, with pull tape silicone lining 1.25-1.5”. Color orange for data.
- C. Shall have sequential markings in feet or meters.

PART 3 EXECUTION

3.1 CONDUIT

- A. Conduit:
 1. Electrical Metallic Tubing and Rigid Metal Conduit are the allowed conduit type. Flexible metal conduit is not allowed, unless noted otherwise or specifically approved by Owner’s Representative.

2. Install with a minimum of bends and offsets. Bends shall not kink or destroy the interior cross section of the raceway. Factory made bends shall be used for raceway's 1" trade size and larger. Bends radius shall be 6 times the internal diameter for conduit sizes up to 2 inches. A conduit greater than 2 inch shall have bend radius at least 10 times the diameter of the conduit.
3. Runs exceeding 100 feet or 180 degrees total bends shall be broken with suitable sized pull or splice boxes. LB or similar conduit fittings are not acceptable.
4. Do not locate riser pull boxes at bends without prior review and approval by owner's representative. Where possible use instead sweeps for the bend and locate in a straight pull nearby.
5. Conduit runs to work areas shall serve no more than one (1) communication outlet and shall be a minimum of 1".
6. Conduits shall be sized to accept 50% future growth, sizing shall account for fire code capacity restrictions.
7. Plug the ends of each roughed-in raceway with an approved cap or disc to prevent the entrance of foreign materials during construction.
8. Secure within three feet of each outlet box, junction box, cabinet or fitting.
9. Label pullboxes as shown on the detail drawings.
10. Provide a #14 AWG fish wire in all "Spare" or "Empty" conduit runs to facilitate future installation of cables.
11. Install raceways in concrete floor slabs as follows:
 - a) All conduits in concrete floor slabs shall be rigid galvanized steel with concrete tight threaded fittings.
 - b) Provide expansion fittings where conduits cross building expansion joints.
 - c) Install conduit below the reinforcing mesh.
 - d) Locate conduits to provide a minimum of 3" of concrete around conduit.
 - e) Obtain approval from the Owner's Representative prior to installing conduit larger than 1" trade size in concrete slabs.
 - f) Wherever a cluster of four-(4) or more conduits rise out of floor exposed, provide neatly formed 4-in. high concrete envelope, with chamfered edges, around raceways.
12. Provide conduit supports based on the following table:

<u>Conduit Trade Size</u>	<u>Type of Run</u>	<u>Horizontal Spacing in Feet</u>	<u>Vertical Spacing in Feet</u>
1", 1 1/4"	Concealed	8	10
1 1/2", & larger	Concealed	10	10
1", 1 1/4"	Exposed	7	8
1 1/2" & larger	Exposed	10	10

13. Where conduits puncture roof, install pitch pockets as required in order that the roof warranty is maintained.
14. Conduit System Installation:
 - a) Cable in exterior, above grade locations: Rigid Galvanized Steel
 - b) Interior locations: Electrical Metallic Tubing
 - c) Cable below grade: PVC Schedule 40
15. Identification: Clearly label conduit at exposed ends indicating closet or outlet where conduit terminates and the length of the conduit. Label pull boxes indicating destination of conduits entering and exiting.
16. Include intra- and inter-building raceways. Including conduits, sleeves and trays for the placement of cables from the communications center to communications closets, from the communications center to the entrance room or space and from communication center to communication center in different building in a campus environment.

B. Conduit fill shall be as follows:

<u>Trade Size</u>	<u>Area of Conduit</u> (Square Inches)	<u>Cat 6 Cable Fill</u> <u>Capacity – 50%</u>	<u>Bend Radius</u>
1"	0.87	6	6"
1 ¼"	1.51	10	07.5"
1 ½"	2.05	15	9"
2"	3.39	20	12"
2 ½"	4.82	30	25"
3"	7.45	40	30"
4"	12.83	70	40"

- C. Backbone pathways shall be in the form of conduits or cable tray and sleeves between the main communication equipment rooms, spaces and closets and shall be provided and sized as shown on drawings:
- D. Fire stop all communications pathways.
- E. Pull boxes shall be marked with "COMM ONLY" using a painted stencil. Coordinate size and color with owner's representative.

- F. Conduits or sleeves shall extend between 4"-6" into telecommunications rooms, vertical conduits shall rise a minimum of 6 inches above the finished floor.
- G. Bush all conduit ends.
- H. Conduits shall be concealed except in the following areas:
 - 1. Mechanical Rooms
 - 2. Electric Rooms
 - 3. Manufacturing areas
 - 4. Garage or maintenance areas
 - 5. Unfinished basements or crawl spaces
- I. Do not install raceways adjacent to hot surfaces or in wet areas.
- J. Install conduits to edges of access boxes so as to maximize the total number of conduits that can be routed through the pull box.
- K. Provide expansion fittings with external grounding straps at building expansion joints.
- L. Do not install conduit horizontally in concrete or block partitions.
- M. Arrange neatly to permit access to the raceway, outlet, pull, and junction boxes, and work installed by other trades.
- N. If it is necessary to burn holes through webs of beams or girders, call such points to the attention of the Owner's Representative and receive written approval both as to location and size of hole before proceeding with work. All holes shall be burned no larger than absolutely necessary.
- O. Core drill, sleeve, and fire stop all penetrations through existing floors.
- P. Support all raceways with malleable iron pipe clamps or other approved method. In exterior or wet locations, provide minimum 1/4" air space between raceway and wall. Secure raceway within 3 ft. of each outlet box, junction box, cabinet or fitting.
- Q. Install junction and pull boxes in readily accessible locations. Equipment, piping, ducts and the like shall not block access to boxes. Provide all necessary junction or pull boxes required due to field conditions and size as required by the National Electrical Code.

3.2 SLEEVES

- A. Support, firestop and size as per drawing.
- B. Provide fire rated assemblies for transition through rated walls and floors.
- C. Sleeves shall be bonded/grounded as required by code
- D. Sleeves shall have an insulated bushing installed prior to the installation of telecommunications cabling.

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- E. Sleeves used at wall transition points for cable tray systems shall be 4". Quantity of sleeves shall be equal to the capacity of the cable tray.
- F. Sleeves for distribution of horizontal cable in renovated areas not having conduits to the cable tray shall be sized so that when all cables have been installed at the completion of the project, the sleeve will be at 50% capacity of the sleeve's maximum fill (maximum fill is based on using a UL listed fire rated assembly [40%]).

3.3 CABLE TRAYS

- A. Support above ceiling Cable Tray using 3/8" threaded, galvanized rod hangers, with rods extended through support steel and double nutted. Size support member within load rating of member section and support every 5'. Install cable tray level and straight.
- B. Provide seismic bracing as required by code.
- C. Provide stiffeners to prevent lateral movement and stabilize cable tray. Provide minimally one stiffener assembly per vertical support (threaded rod).
- D. Cable trays shall have a minimum of 36" headroom above and 1' of side clearance.
- E. Provide steel body expansion connectors at building expansion joints. Minimum 4-in. movements, greater if expansion movement conditions warrant.
- F. Provide external grounding strap at expansion joints, sleeves, crossovers and at other locations where tray continuity is interrupted.
- G. Provide necessary elbows, tees, crosses, risers, offsets, fittings, reducers, connectors, clamps, rod suspension, trapeze hangers, etc., as required to make a complete job, coordinate with the manufacturer.
- H. Provide (1) 6" long piece of EMT conduit on each threaded rod hanger to prevent scoring of cable insulation when cable is pulled in.
- I. Cable Trays shall not pass through any wall or fire-rated barrier. Cable tray shall end before the wall and transition to:
 - 1. Non rated walls: 4" EMT sleeves with connectors and insulated bushings as called for in this specification section. The capacity of sleeves shall minimally provide equivalent capacity to the adjoining cable tray unless otherwise noted.
 - 2. Rated wall/floor: Fire rated assembly with the same or greater rating as the wall or floor, the capacity of sleeves shall minimally provide equivalent capacity to the adjoining cable tray unless otherwise noted.

3.4 CABLE HANGERS/ J HOOKS

- A. Provide cable hangers a maximum of 3' on center wherever cable tray or conduit is not present for support low voltage cabling.

- B. Provide J Hooks below a raised floor a maximum of 2' on center and 2" above the concrete.
- C. Ceiling ties and rods shall not be used to hang cable or cable supports without the approval of the owner's representative.
- D. Load hangers as recommended by the manufacturer. Provide hangers side by side on a common bracket where cable quantities require.
- E. Do not install cables loose above lock-in type, drywall or plaster ceilings.
- F. Cables shall be installed at least 3 in. above the ceiling tiles and shall not touch the ceiling.
- G. Do not support cable from ceiling system tie wires or grid.
- H. Provide a minimum of 2 spare bracket mounted hangers in new construction.

3.5 SURFACE RACEWAY

- A. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.
- B. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.
- C. Electrical Security: Metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.
- D. Raceway Support: Raceway shall be supported at intervals not exceeding 5 feet or in accordance with manufacturer's installation sheets.
- E. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.
- F. Unused Openings: Close unused raceway openings using manufacturers recommended accessories.
- G. Coordinate mounting height of new surface raceway with existing conditions. Verify in field with owner's representative prior to installation.

3.6 BOXES AND CABINETS

- A. Consider location of outlets shown on drawings as approximate only. Study architectural, electrical, process piping, mechanical, plumbing, structural, roughing-in, etc., drawings and note surrounding areas in which each outlet is to be located. Locate outlet so that when fixtures, motors, cabinets, equipment, etc., are placed in position, outlet will serve its desired

purpose. Where conflicts are noted between drawings, contact Owner's Representative for decision prior to installation.

- B. Outlet boxes in separate rooms shall not be installed "back-to-back" without the approval of the Owner's Representative.
- C. Outlet boxes shall be sized to accommodate the wiring device(s) to be installed.
- D. Outlet boxes installed in plaster, gypsum board or wood paneled walls shall be installed with raised plaster covers or raised tile covers.
- E. Outlet boxes installed in tile, brick or concrete block walls shall be installed with extra-deep type raised tile covers or shall be 3-1/2" deep boxes with square corners and dimensions to accommodate conductors installed.
- F. Surface ceiling mounted outlet boxes shall be minimum 4" square, 1-1/2" deep, galvanized sheet metal.
- G. Surface wall mounted metallic outlet boxes shall be cast type boxes having threaded or compression type threadless hubs. Exterior boxes shall be cast type with threaded hubs and gasketed cover plates secured by non-ferrous screws.
- H. Where structural or other interference prevent compliance with mounting heights listed, consult Owner's Representative for approval to change location before installation.
- I. Where communications outlets are shown on, behind, below or above furniture or millwork. Verify the exact location and mounting height with the Owners representative. The electrical contractor shall be responsible for moving all communications outlets that are in conflict with furniture or millwork, including cutting, patching and painting, at no cost to the owner.
- J. Pull boxes shall have a distance between each raceway entry inside the box and the opposite wall of the box of at least 6 times the trade-size diameter of the largest raceway, this distance being increased by the sum of the trade size diameters of the other raceways on the same wall of the box and have a distance between the nearest edges of each raceway enclosing the same conductor of at least 6 times the trade size diameter of the raceway or 6 times the trade size diameter of the larger raceway if they are of different sizes.
- K. Install outlet boxes as per sizes indicated on the drawings and in the specifications.

3.7 SUPPORTING DEVICES

- A. Hangers and Supports:
 - 1. Provide steel angles, channels and other materials necessary for the proper support of wall-mounted cabinets, racks, panels, etc.
 - 2. Threaded rod used for support of conduit or raceways shall be minimum 3/8" O.D.
 - 3. Cabinets, large pull boxes, and cable support boxes shall be secured to ceiling and floor slab and not supported from conduits. Small equipment boxes, etc., as approved by Owner's Representative, may be supported on walls. Racks for support of conduit and

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heavy equipment shall be secured to building construction by substantial structural supports.

3.8 GENERAL

- A. Support raceways from building construction. Do not support raceways from ductwork, piping, or equipment hangers.
- B. Support outlet, pull, and junction boxes independently from building construction. Do not support from raceways.
- C. Coordinate all raceway runs with other trades.
- D. All open raceways shall be installed a minimum of 6 in. away from any light fixture or other source of EMI (Electro-magnetic interference).
- E. All horizontal pathways shall be bonded and grounded per the NEC Article 250 and TIA/EIA-J-STD-037.
- F. In all cases horizontal pathways shall be sized for a minimum of 50% future growth.
- G. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 270528

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

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. Telecommunications mounting elements.
2. Telecommunications equipment racks and cabinets.
3. Grounding
4. Patch Panels

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. LAN: Local area network.
- C. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 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. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.6 QUALITY ASSURANCE

- A. Equipment and materials shall be of the quality and manufacture indicated. Model numbers, part numbers and nomenclature for manufacturers listed are used in the specification for the purpose of minimum requirement standards and basis of design.

PART 2 - PRODUCTS

2.1 FLOOR MOUNT CABINET

- A. Floor mounted Cabinet 84" tall (44 RMU) x 24" W x 36" D UL Listed to UL60950-1, fully welded 16 gauge cold rolled steel, 2 pairs of EIA -310- E compliant 19" mounting rail system, Black powder coat finish, vented steel front door, top panel with fans, vented steel rear door, locking lift off solid side panels.
- B. Design make: Legrand, Great Lakes, Panduit or approved equal

2.2 FLOOR MOUNTED DATA RACK

- A. 7' Tall (45RMU) with 6" deep posts, 19" rack mounting space, floor mounted, steel construction, 18" base with (4) $\frac{3}{4}$ " bolt holes, baked black polyester powder coat finish. Rack shall have double sided 12/24 tapped holes spaced $\frac{5}{8}$ " to $\frac{5}{8}$ " to $\frac{1}{2}$ " standard EIA 310-E hole pattern. Provide screws for all equipment plus 25% spare. Rack shall have integral grounding lug. Provide one 10" shelf.
 - 1. Design make: Legrand OR-19-84-6T2SDB, Cooper B-Line SB813084FB or Siemon RS3
- B. Vertical cable management, shall have integrated wire retaining fingers, baked polyester powder coat finish, front and rear channels with covers.
 - 1. Design make: Siemon, Panduit or Cooper B-line. Provide cable management on one side of each rack.
- C. Horizontal cable management panels, single sided, to be plastic enclosed with flexible fingers, dual hinged cover, 19" rack mount.
 - 1. Design Make – Ortronics SHMC2RU or equal

2.3 WALL MOUNT RACK

- A. 38" high x 25" deep, 19" rack mounting space, wall mounted with swing out rack face, steel construction, baked polyester powder coat finish. Rack pattern shall have 12/24 tapped holes,

5/8" - 5/8" -1/2" standard EIA 310-D hole pattern. Provide screws for all equipment plus 25% spare.

1. Design make: Legrand OR-19-35-T25DHYDTB, Cooper B-Line, or Siemon

2.4 POWER DISTRIBUTION UNIT

- A. Power Distribution Units: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. AC voltage input 120V, 20A, Rack mounting, 1 RU, six foot cord.
3. Six (6), 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
4. LED indicator lights for power and protection status.
5. Short circuit rating 13000Amps(12000Amps L-N, 12000Amps L-G, 12000 Amps N-G) .
6. Response time <1ns.
7. Rocker-type on-off switch, illuminated when in on position.
8. Coordinate with Owner for exact input and output required voltages.
9. Design Make: Wiremold R5BZ20 or equal.

2.5 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

- B. Telecommunications Ground Bar:

1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V
4. Design make – FCI Burndy, Erico, Cooper B-Line.

- C. Comply with J-STD-607-A.

2.6 CABLE RUNWAY

- A. Cable runway, shall be constructed of 1.5" hollow tubular side rails, and 1" tubular rungs fully welded. System shall be manufactured from high strength carbon steel, ASTM A 513 and finished in black powder coat. Provide widths as shown on drawings.
- B. Include connecting and support hardware to suit the installation. Including but not limited to curved runway dropouts, 90 degree elbows, horizontal and 90 degree connectors, open clamp kits for threaded rod supports, wall angle assembly, wall shelf bracket, cable fence, vertical wall bracket, and protective sleeves.
- C. Design make: Legrand Cable Runway.

2.7 LABELING

- A. Comply with TIA/EIA-606-A and UL 969 and spec section 271700 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.8 CATEGORY 6 AND 6A UTP PATCH PANELS

- A. Rack mounted, 48 port 2U patch panels, panels shall match jack manufacturer, with rear cable support bracket. Shall fit standard 19" rack. Provide wall mount brackets where required.
- B. Design make: Shall match jack manufacturer.

2.9 PATCH CABLES

- A. Cat 6 patch cables.
 - 1. Shall have stranded conductors, and meet cat 6 performance criteria.
 - 2. Shall be Blue, to match horizontal cabling.
 - 3. Shall be various sizes to accommodate patching. 50% 2' and 50% 4'.
 - 4. Provide one patch cable per patch panel port as shown on the drawings.
 - 5. Design make: Shall match cable manufacturer.
- B. Fiber Optic Jumpers.
 - 1. Shall be two (2) strands OFNR rated, aqua for MM, and two (2) strands yellow for single mode.
 - 2. Provide two (2) 3m OM4 multimode and three (3) 1m OM4 multimode per telecom room (TR). Provide two (2) 3m SM per parking lot camera.
 - 3. Connector types to be the same as called for in spec section 271300 and field verified for owner equipment.
 - 4. Design make – Shall match cable type and manufacturer or equal

2.10 OPTICAL FIBER PATCH PANELS

- A. Rack mount fiber panels shall be 19" rack mounted, appropriately sized for the number of strands in a rack. Sized to accommodate splices and connectors. Provide 12 port LC adaptor plates.
 - 1. Design Make: Corning PCH-04U, Legrand, Leviton 2000i-SDX
- B. Wall mount fiber panels shall be sized to accommodate the fiber strand count installed, provide 12 port LC adapter plates.
 - 1. Design make: Corning ECL-W3P, Legrand, Leviton.

2.11 TERMINATION BLOCKS

- A. Shall be 50 pair, M1-50 type 66 blocks
- B. Design Make: Siemon S66M1-50

2.12 CABLE MANAGEMENT

- A. Hook and Loop Ties
 - 1. Design Make: Siemon, Legrand

2.13 SPLICE ENCLOSURE

- A. Splice cases shall be fully gasketed to prevent ingress of water, re-enterable and suitable for underground and manhole use, appropriately sized for the number of strands/cables to be spliced, splice trays to match case and provide space for the number of strands and splice cover. Acceptable manufacturers: 3M, Fiber instrument sales, Fiber Savvy or EQUAL
- B. All splices shall be of the fusion splice type. Splice loss shall not exceed 0.15dB. Splice covers to be heat shrinkable.
- C. Should fiber be broken during installation, the entire run shall be replaced

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- C. Bundle, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools. Use of plastic ty-raps is prohibited, use Velcro straps.
- D. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 - 2. Record agreements reached in meetings and distribute them to other participants.

- 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
 - 4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
- E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
- 3.2 EQUIPMENT CABINETS
- A. All cabinets shall be anchored to the floor, install horizontal cable management and patch panels as shown on the drawings.
 - B. Mount with a minimum of 36 inches of clear access behind and in front of the rack where possible.
- 3.3 CABLE SUPPORT
- A. Keep horizontal wall mount cable runs to a minimum. In general horizontal runs shall be on wall mounted cable runway. Install distribution rings 2' on center for all exposed wall mounted cable runs. Cabling installed vertically shall be supported by vertically installed cable runway.
 - B. All cables shall be neatly "dressed out" in equipment rooms.
- 3.4 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. All penetrations shall be fire stopped.
- 3.5 FIRESTOPPING
- A. Comply with TIA-569-B, Annex A, "Firestopping."
 - B. Comply with BICSI TDMM, "Firestopping Systems" Article.
- 3.6 GROUNDING
- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter and spec section 270526 "Grounding and Bonding for Communications Systems".
 - B. Comply with J-STD-607-A.
 - C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

- D. Bond metallic equipment, including racks, cable tray and conduit to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

- 1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Section 271700 "Testing and Identification."
- B. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A. comply with requirements in Section 271700 "Testing and Identification"
- C. Labels shall be preprinted or computer-printed type

3.8 PATCH PANELS

- A. Install patch panels as per rack elevation details, provide support on the rear of the rack for cat 6 cable, Terminate cat 6 cable per TIA and BICSI Standards. Leave 8' of cable slack coiled either in the rack or coiled on the back board.

END OF SECTION 271100

SECTION 275123 - INTERCOMMUNICATIONS AND PROGRAM 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: Air Traffic Control Tower Air to Ground radios-main and standby, ATIS system including radio, emergency Air to Ground radio, integrated voice switch, touch screen console displays, voice recording system.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For intercommunications and program systems. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Include scaled drawings for master station that detail built-in equipment.
 - 3. Wiring Diagrams: For power, signal, and control wiring.
 - a. Identify terminals to facilitate installation, operation, and maintenance.
 - b. Single-line diagram showing interconnection of components.
 - c. Cabling diagram showing cable routing.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For intercommunications and program systems to include in operation and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. A record of Owner's equipment-programming option decisions.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. 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.
- C. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate layout and installation of blue light phones with other site construction, and with owners IT personnel.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: The following manufacturers can provide products compatible with the specifications.
 - 1. General Dynamics
 - 2. Frequentis
 - 3. Taco
 - 4. iCom
 - 5. Motorola
 - 6. Eventide

2.2 RADIOS

- A. Ground to Air radios, based on FAA NEXCOM Segment 2 requirements. Provide software defined digital, voice over IP capable advanced network ready VHF, UHF, rack mounted ground to air communications radios.
 - 1. Front panel display and keyboard.
 - 2. Passively cooled, no fan required
 - 3. SNMPv3 with ethernet.
 - 4. VHF:112-150MHz, 25kHz channel spacing
 - 5. UHF: 225-399.975MHz, 25kHz channel spacing
 - 6. Low power transmitter 2-12 Watts with co-site filter, 2-15Watts without filter.
 - 7. High power transmitter 12-35Watts with co site filter, 12-50Wattswithout filter.
 - 8. Remote control and maintenance capability with SNMP and built-in test.

- 9. 100% usable receive channels.
- B. DC Power supply: 24VDC nominal AC V 50-60 Hz automatic AC-DC switchover power supply.
- C. Antennas: Provide antennas compatible with the site and the frequency required.
- D. Manufacturer: General Dynamics CM-300 (V2) or equal

2.3 ATIS

- A. The ATIS shall provide the means for a remote user to communicate with a system operator.
- B. Automatically receives ATIS weather information from the facility's existing weather data source.
 - 1. Combines weather information with airport operational data, field conditions and NOTAMS to produce an ATIS message in a little as 30 seconds.
- C. Text to speech technology.
- D. Compliant with all ICAO and GRF requirements
- E. Provide GRF functionality to broadcast RCR data for all weather conditions and runway contaminants, including snow, ice and wet runway conditions.
- F. Supports ATIS voice broadcast over VHF radio using analog and / or ED-137 compliant VoIP.
- G. Automatically logs received data, broadcast content and user actions.
- H. Manufacturer and Make: Frequentis 3020X or equal.

2.4 INTEGRATED VOICE SYSTEM

- A. Sunlight readable touch panel displays.
- B. External speakers and volume control
- C. Provide headsets.
- D. 4-Jack feature
 - 1. Routes all A/G & G/G audio to all four jacks. Provides transmit pre-emption:
 - a. Primary monitor (highest priority)
 - b. Primary operator
 - c. Secondary monitor
 - d. Secondary operator,
- E. Tone mitigation safety features
 - 1. Eliminates / reduces the continuing tone noise events
 - 2. Tone notch filter-detects unwanted tones and removes from headset audio path.
 - 3. Headset limiting-provides audio compression after the tone notch to limit maximum total audio volume to operator's ear.

F. Manufacturer and Make: Frequentis 3020X VCS or equal

2.5 BACK UP RADIO

A. Provide a VHF air band transceiver.

1. VHF Frequency range: 115-150MHz
2. UHF Frequency range: 225-399.995MHz
3. Tuning Increments: 25kHz, 12.5kHz, 5kHz and 8.33kHz
4. SNMP V3 command / control BIT
5. 20 Channel presets: Independently programmable transmit and receive
6. Transmitter:
 - a. Output power
 - 1) 1-7W (CW) user adjustable in 0.2Watt steps
 - 2) 10W avg \pm 1dB @90% AM
 - 3) FM: 1 to 10 Watts user adjustable in 0.2 Watt steps
 - b. Spurious emission -60dB.c
 - c. Modulation limiting – 70% (Maximum 98%).
 - d. Microphone impedance – 600ohms.
7. Receiver:
 - a. Sensitivity: AM -103dBm, FM -114dBm, receiver dynamic range 118dB.
 - b. Selectivity:
 - 1) 25Khz spacing: \pm 3 kHz/ \pm 22 kHz.
 - 2) 8.33 kHz spacing: \pm 2.778 kHz/ \pm 7.37 kHz.
8. OLED Display
9. Audio output power -External 50W amplifier.

B. Manufacturer: General Dynamics URC-300 VHF/UHF Transceiver or equal.

2.6 VOICE RECORDING

A. Mission critical 24/7 IP Based communications recording solution.

B. Physical Characteristics

1. 19" rack mounted.
2. 96 analog channels.
3. 560 VoIP channels.
4. 96 Digital PBX channels
5. 192/240 T1/E1.
6. 240+ P25.
7. 240+ DMR

C. Radio systems; RoIP, trunked and conventional 2-way radio, Motorola Astro with AIS, I3Harris VIDA P25, EFJohnson Atlas P25, Motorola Motorbo, L3Harris/Tait DMR Tier 3, L3Harris /Tait MPT-IP Sepura/Flyde DMR Tier 3, Icom IDAS Conventional, Kenwood NextEdge Trunked, ESChat PTT over LTE, PC Screens and more.

D. Manufacturer: Eventide Nexlog 740DX-series or equal.

2.7 ANTENNA

- A. Provide antennas and antenna mounts and masts for each radio, VHF and UHF installed.
- B. Provide LMR 400 coax cabling with connectors or manufacturer recommended cabling for all antennas.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings
 - 2. Install duct rated cable in underground pathways.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Terminate and test cat 6 cables to cat 6 standards TIA 568.D,
- D. Coordinate with Owner for exact termination locations.

3.2 INSTALLATION OF RACEWAYS

- A. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.3 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements:
 - 1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 - 2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
 - 3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

3.4 INSTALLATION

- A. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
- B. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

3.5 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

3.6 SYSTEM PROGRAMMING

- A. Programming: Owner to provide programming for existing network and VoIP phone system equipment.

3.7 STARTUP SERVICE

- A. Perform startup service and initial system programming.
 1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 2. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain the intercommunications and program systems.
 1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.
 2. Provide 6 hours of training divided into 2-3 training classes.

END OF SECTION 275123

SECTION 281300 - ACCESS CONTROL

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. Components for security access control.
 - 2. Security access controllers connected to high-speed electronic-data transmission network.

1.3 DEFINITIONS

- A. CCTV: Closed-circuit television.
- B. CPU: Central processing unit.
- C. Credential: Data assigned to an entity and used to identify that entity.
- D. dpi: Dots per inch.
- E. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- F. GFI: Ground fault interrupter.
- G. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- H. I/O: Input/Output.
- I. LAN: Local area network.
- J. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.

- K. PC: Personal computer. Applies to the central station, workstations, and file servers.
- L. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.
- M. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.
- N. RAS: Remote access services.
- O. RF: Radio frequency.
- P. ROM: Read-only memory. ROM data are maintained through losses of power.
- Q. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- R. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- S. UPS: Uninterruptible power supply.
- T. USB: Universal serial bus.
- U. WAN: Wide area network.
- V. WAV: The digital audio format used in Microsoft Windows.
- W. WMP: Windows media player.
- X. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- Y. Windows: Operating system by Microsoft Corporation.
- Z. Workstation: A PC with software that is configured for specific, limited security-system functions.
- AA. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.

- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.
- C. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.
- D. Other Action Submittals:
 - 1. Project planning documents as specified in Part 3.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. Include the following:
 - 1. Microsoft Windows software documentation.
 - 2. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
 - 3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
 - 4. System installation and setup guides with data forms to plan and record options and setup decisions.

1.7 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. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.
- 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. Comply with NFPA 70, "National Electrical Code."
- E. Comply with SIA DC-01 and SIA DC-03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The airport currently has the GENETEC Security Center. All components installed should be compatible with the system. All licensing and programming for the system shall be provided under this contract.

2.2 PHYSICAL ACCESS CONTROL SYSTEM PANEL HARDWARE

- A. Provide network door controllers, and associated components outlined in this section, and as shown on the project plans. The network door controllers shall provide access control processing, host functioning and power for single/double door configurations. This includes the reader, lock, door status, request-to-exit device, and auxiliary devices. It shall provide full distributed processing of all access control functions. The unit shall provide fully functional off line operation when not actively communicating with the host access control software application; performing all access decisions and event logging. Upon connection with the host access control software application, the network door controller or network controller/reader shall upload all buffered off-line transactions to the host software.
- B. Door Control Module
 1. Communicates to master controller via RS485
 2. Capable of connecting two doors
 3. On-board relay outputs
 4. Status LED for host communication and heartbeat.

5. Variable resistor values for line supervision.
6. Downloadable firmware.
7. Operating Temperature: 32° to 158° F, Operating Humidity: 0-95% RHNC.
8. UL 294 and 1076-listed, CE marked, RoHS compliant.
9. Compatible with Genetec Synergis Master Controller
10. HID VertX V100 Two Door Controller

- C. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations

2.3 CARD READER

- A. Provide a card reader as called out on drawings compatible with the existing prox card technology utilized by the facility.
1. The card reader shall read encoded data from the access card and/or transponder and transmit the data back to the host panel, giving an audible and visual indication of a properly read card.
 2. The card reader shall have a typical read range of 2” to 3.5”, when used with an HID Corporation proximity card which shall be compatible with the existing equipment and utilize the existing facility code.
 3. The card reader shall be provided with an internal tamper switch that will indicate an alarm condition if an unauthorized attempt is made to disassemble the unit.
 4. The card read shall have an integral card reader and be configure to activate with card or pin.
 5. The card reader shall be compatible with the existing system protocol interface, and be compatible with all existing access control system.
 6. Operating voltage: 5-16VDC, current requirements: (average/peak) 85/169 mA
 7. Cabling requirements shall be: Cable distance: (Wiegand): 500 feet (150m), Cable type: 5-conductor #22 AWG w/overall shield, Standard reader termination: 18” (.5m) cable pigtail or optional terminal strip
 8. Warranty of contactless multi class card readers shall be lifetime against defects in materials and workmanship.

Make and Model: HID Multiclass SE Reader RPK40 for entrance doors

2.4 RECESSED MOUNT POSITION SENSOR (DOOR CONTACTS)

- A. Provide door contacts where called for on the contract drawings that meet the following requirements.
1. Self locking mounting.

2. Rugged construction.
3. 15/16" diameter.
4. UL approved for specific fire doors.
5. ABS Plastic construction.
6. Response time: 1 msec max.
7. Life Cycles: 100,000 under full load, 10,000,000 under dry circuit.
8. Lead types #22 wire.
9. UL listed.

Make and model: General Electric SENTROL 1078 series or approved equal.

2.5 REQUEST TO EXIT DETECTOR

- A. Provide request to exit detectors where called for on the contract drawings that meet the following requirements.

1. Single or double door use.
2. Wall or ceiling mountable.
3. Internal vertical pointability.
4. Wrap-around coverage pattern.
5. Selectable relay trigger mode.
6. Selectable fail safe/fail secure modes.
7. Externally visible activation LED.
8. 26mA at 12VDC.
9. Alarm output: Two form C relay contacts.
10. Relay latch time: Adjustable to 60 seconds.
11. Operating Temperature: -20° to 120° F.
12. UL 294 listed, CE approved.

Make and model: Bosch DS160i or approved equal

2.6 ELECTRIC STRIKE

- A. Provide electric strike for doors where called for on the contract drawings that meet the following requirements.

1. Tamper resistant, heavy duty construction.
2. Constructed entirely of stainless steel for strength and corrosion resistance.
3. Static strength 1,500 lbs.
4. Dynamic strength 70 ft-lbs.
5. Endurance 500,000 cycles.
6. Horizontally adjustable keeper to allow for door and frame adjustment.
7. Deadlatch tabs included.
8. 3/4" keeper depth
9. Non-handed
10. Fail Secure

11. Plug-in conductor
12. Full keeper shim
13. Five year limited warranty
14. Field verify all strikes prior to ordering to ensure the proper model number or strike type is ordered.

Make and model: HES 1500 series or equal.

2.7 POWER SUPPLY

A. Access control power supply

1. Product Description:
 - a. 12VDC/24VDC selectable output
 - b. 115VAC input voltage
 - c. Filtered and electronically regulated Output
 - d. Short circuit and regulated output
 - e. Automatic switch over to stand-by battery
 - f. Fused battery protection
 - g. Provide Two (2) 7AH batteries
 - h. AC Fail supervision
 - i. Dimensions: 13.5" (L) x 13" (W) x 3.25"(H)

Make and Model: Altronix AL600ULX or engineer approved equal.

B. Access Control Output Board

1. Product Description:
 - a. 12VDC/24VDC selectable output
 - b. 28VAC or DC Input at 14A max
 - c. Shall have 8 fused outputs
 - d. Shall be mounted in same enclosure as the AL600ULX

Make and Model: Altronix PD8 or engineer approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

- B. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA/EIA 606-A, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.
 - 1. Record setup data for control station and workstations.
 - 2. For each Location, record setup of controller features and access requirements.
 - 3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
 - 4. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
 - 5. Assign action message names and compose messages.
 - 6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
 - 7. Prepare and install alarm graphic maps.
 - 8. Develop user-defined fields.
 - 9. Develop screen layout formats.
 - 10. Propose setups for guard tours and key control.
 - 11. Discuss badge layout options; design badges.
 - 12. Complete system diagnostics and operation verification.
 - 13. Prepare a specific plan for system testing, startup, and demonstration.
 - 14. Develop acceptance test concept and, on approval, develop specifics of the test.
 - 15. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.
- D. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.3 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."
- B. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- D. Install LAN cables using techniques, practices, and methods that are consistent with Category 5E rating of components and fiber-optic rating of components, and that ensure Category 6 and fiber-optic performance of completed and linked signal paths, end to end.
- E. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- F. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.4 CABLE APPLICATION

- A. Comply with TIA 569-B, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. TIA 232-F Cabling: Install at a maximum distance of 50 ft. (15 m).
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. (1220 m).
- E. Card Readers and Keypads:
 - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
 - 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft. (75 m), and install No. 20 AWG wire if maximum distance is 500 ft. (150 m).
 - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
 - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 ft. (75 m).
- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. (8 m).

3.5 GROUNDING

- A. Comply with Division 26.
- B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Signal Ground:
 - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
 - 2. Bus: Mount on wall of main equipment room with standoff insulators.
 - 3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.6 INSTALLATION

- A. Push Buttons: Where multiple push buttons are housed within a single switch enclosure, they shall be stacked vertically with each push-button switch labeled with 1/4-inch- (6.4-mm-) high text and symbols as required. Push-button switches shall be connected to the controller associated with the portal to which they are applied, and shall operate the appropriate electric strike, electric bolt, or other facility release device.
- B. Install card readers, keypads, push buttons, and biometric readers.

3.7 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Division 26.
- B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - 1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.

2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

D. At completion, cable and asset management software shall reflect as-built conditions.

3.8 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.9 FIELD QUALITY CONTROL

- A. 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.

- B. Tests and Inspections:

1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, Category 5 tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA 568-B.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA 568-B.1.
2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
4. Comply with applicable specification in Division 01.

- C. Devices and circuits will be considered defective if they do not pass tests and inspections.

- D. Prepare test and inspection reports.

3.10 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.11 PROTECTION

- A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.12 DEMONSTRATION

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system.

- A. Develop separate training modules for the following:
 1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
 2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
 3. Security personnel.
 4. Hardware maintenance personnel.
 5. Corporate management.

END OF SECTION 281300