

SECTION 02 41 19 - SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Selective Building Demolition:
 - 1. Selective demolition of ceiling systems designated to be removed.
 - 2. Selective demolition of concrete required to be removed.
 - 3. Protection of portions of building adjacent to or affected by selective demolition.
 - 4. Removal and legal disposal of materials.

1.2 RELATED SECTIONS

- A. Section 03 30 00 – Cast-in-Place Concrete
- B. Section 09 51 00 – Acoustical Ceilings.

1.3 SUBMITTALS

- A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

1.4 QUALITY ASSURANCE

- A. Codes and Regulations: Comply with governing codes and regulations. Use experienced workers.

1.5 PRE-DEMOLITION MEETINGS

- A. Convene minimum two weeks prior to starting work of this section.

1.6 SEQUENCING

- A. Immediate areas of work will not be occupied during selective demolition. Authorized school staff and students, may occupy adjacent areas.
- B. No responsibility for buildings and structures to be demolished will be assumed by the Owner.
- C. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

PART 2 - PRODUCTS - Not applicable to this Section.

PART 3 -EXECUTION

1.7 SELECTIVE DEMOLITION

- A. Demolition Operations: Do not damage building elements and improvements indicated to remain. Items of salvage value, not included on schedule of salvage items to be returned to Owner, shall be removed from structure. Storage or sale of items at project site is prohibited.
- B. Shoring and Bracing: Provide and maintain interior and exterior shoring and bracing.

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- C. Occupied Spaces: Do not close or obstruct streets, walks, drives or other occupied or used spaces or facilities without the written permission of the Owner and the authorities having jurisdiction. Do not interrupt utilities serving occupied or used facilities without the written permission of the Owner and authorities having jurisdiction. If necessary, provide temporary utilities.
- D. Operations: Cease operations if public safety or remaining structures are endangered. Perform temporary corrective measures until operations can be continued properly.
- E. Security: Provide adequate protection against accidental trespassing. Secure project after work hours.
- F. Restoration: Restore finishes of patched areas.

1.8 SCHEDULE

Items for Protection During Demolition and Construction:

- 1. All existing walls, doors, windows and flooring.
 - 2. Vinyl wall coverings in areas of ceiling removal.
 - 3. Existing ceiling mounted troffer luminaires to remain in place throughout construction. Assure that luminaires are properly wired from above to support prior to removal of ceiling system. See Specification Section 09 51 00 – Acoustical Ceilings.
 - 4. Existing security devices and monitors mounted on ceilings.
 - 5. Furnishings throughout. Install drop cloths over all areas, including book shelving, desks, chairs, etc., that will require protection from construction dust and/or debris.
- B. Utilities Requiring Interruption, Capping, or Removal:
- 1. See Mechanical and Electrical Specifications and drawings for mechanical and electrical requirements.

END OF SECTION

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section specifies cast-in place concrete, including formwork, reinforcing, mix design, placement procedures and finishes.
- B. Concrete paving and walks are specified elsewhere in these specifications.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Concrete Mix Design: Submit to Architect for review. Mix designs shall be designed by a qualified testing laboratory and wet stamped by a Registered Nevada Civil Engineer. Submit written reports to Architect of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until proposed mix designs have been reviewed by Architect.
- C. Product data: For proprietary materials and items, including reinforcement and forming accessories, patching compounds, waterstops, joint systems, curing compounds, and others as requested by Architect.
- D. Shop drawings: For reinforcement, prepared by registered Professional Engineer for fabrication, bending, and placement of concrete reinforcement. Comply with ACI SP-66 (88), "ACI Detailing Manual," showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement. Include special reinforcement required for openings through concrete structures.
- E. Laboratory test reports: For concrete materials and mix design test.
- F. Materials certificates: In lieu of materials laboratory test reports when permitted by Architect. Materials certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.

1.4 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 - i. ACI 318, "Building Code Requirements for Reinforced Concrete."
 - ii. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice."
- B. Concrete Testing Service: Engage a testing laboratory acceptable to Architect to perform material evaluation tests and to design concrete mixes.
- C. Materials and installed work may require testing and retesting at any time during progress of

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work. Tests, including retesting of rejected materials for installed work, shall be done at Contractor's expense.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.
- B. Form Coatings: Provide commercial formulation form-coating compounds with a maximum VOC of 350 mg/l that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
- C. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that will leave no metal closer than 1-1/2 inches to exposed surface.

2.2 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
- B. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire-bar-type supports complying with CRSI specifications. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

- A. Portland Cement: Use one brand of cement throughout project unless otherwise acceptable to Architect.
- B. Concrete in contact with soil: ASTM C 150, Type V, minimum 5-1/2 sacks of cement per cubic yard and water/cement ratio of 0.55 by weight.
- C. All other concrete: Type II.
- D. Fly Ash: ASTM C 618, Type F. See Drawings for additional requirements.
- E. Normal Weight Aggregates: ASTM C 33 and as herein specified. Provide aggregates from a single source for exposed concrete.
- F. For exterior exposed surfaces, do not use fine or coarse aggregates containing spalling-causing deleterious substances.
- G. Local aggregates not complying with ASTM C 33 but that special tests or actual service have shown to produce concrete of adequate strength and durability may be used when acceptable to Architect.
- H. Water: Drinkable.
- I. Admixtures: None allowable.

2.4 RELATED MATERIALS

- A. Granular Base: Evenly graded mixture of fine and coarse aggregates to provide, when compacted, a smooth and even surface below slabs on grade.
- B. Sand Cushion: Clean, manufactured or natural sand.
- C. Vapor Barrier: Provide vapor barrier cover over prepared base material below slabs on grade.

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- i. Polyethylene sheet not less than 6 mils thick.
- D. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- E. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.
 - i. Waterproof paper.
 - ii. Polyethylene film.
 - iii. Polyethylene-coated burlap.

2.5 AVAILABLE PRODUCTS

A. Water-Based Acrylic Membrane Curing Compound: ASTM C 309, Type I, Class B.

- i. "Highseal," Conspec Marketing and Mfg. Co.
- ii. "Safe Cure and Seal," Dayton Superior Corp.
- iii. "Aqua-Cure," Euclid Chemical Co.
- iv. "Dress & Seal #18WB," L&M Construction Chemicals, Inc.
- v. "Masterseal W," Master Builders, Inc.
- vi. "Intex," W.R. Meadows, Inc.
- vii. "Sika Membrane," Sika Corp.

B. Bonding Compound: Polyvinyl acetate or acrylic base.

- i. Polyvinyl Acetate (Interior Only):
 - a) "Superior Concrete Bonder," Dayton Superior Corp.
 - b) "Euco Weld," Euclid Chemical Co.
 - c) "Weld-Crete," Larsen Products Corp.
 - d) "Everweld," L&M Construction Chemicals, Inc.
- ii. Acrylic or Styrene Butadiene:
 - a) "Acrylic Bondcrete," The Burke Co.
 - b) "Strongbond," Conspec Marketing and Mfg. Co.
 - c) "Day-Chem Ad Bond," Dayton Superior Corp.
 - d) "SBR Latex," Euclid Chemical Co.
 - e) "Daraweld C," W.R. Grace & Co.
 - f) "Hornweld," A.C. Horn, Inc.
 - g) "Everbond," L & M Construction Chemicals, Inc.
 - h) "Acryl-Set," Master Builders Inc.
 - i) "Intralok," W.R. Meadows, Inc.
 - j) Sonocrete," Sonneborn-Rexnord.

C. Epoxy Adhesive: ASTM C 881, two-component material suitable for use on dry or damp surfaces. Provide material "Type," "Grade," and "Class" to suit project requirements.

- i. "Burke Epoxy M.V.," The Burke Co.
- ii. "Spec-Bond 100," Conspec Marketing and Mfg. Co.
- iii. "Euco Epoxy System #452 or #620," Euclid Chemical Co.
- iv. "Epoxite Binder 2390," A.C. Horn, Inc.
- v. "Epabond," L&M Construction Chemicals, Inc.
- vi. "Concresive 1001," Master Builders, Inc.

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vii. "Sikadur 32 Hi-Mod," Sika Corp.

2.6 PROPORTIONING AND DESIGN OF MIXES

- A. Limit use of fly ash to not exceed 15 percent of cement content by weight.
- B. Design mixes to provide normal weight concrete with the following properties, as indicated on drawings and schedules:
 - a. Structural Concrete: 3000-psi, 28-day compressive strength.
 - b. Exterior walks, curbs and gutters: 3000-psi, 28-day compressive strength with aire entrainment of 6% +/- 1%.
- C. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:
 - a. Ramps, slabs, and sloping surfaces: Not more than 5 inches.
 - b. Reinforced foundation systems: Not less than 1 inch and not more than 5 inches.
 - c. Other concrete: Not more than 5 inches.

2.7 CONCRETE MIXING

- A. Ready-Mix Concrete: Comply with requirements of ASTM C 94, and as specified.
 - a. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

- A. GENERAL
 - a. Coordinate the installation of joint materials and vapor barriers with placement of forms and reinforcing steel.
- B. FORMS
 - a. General: Design, erect, support, brace, and maintain formwork to support vertical and lateral, static and dynamic loads that might be applied until concrete structure can support such loads. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances complying with ACI 347.
 - b. Construct forms to sizes, shapes, lines, and dimensions shown and to obtain accurate alignment, location, grades, level, and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide backup at joints to prevent leakage of cement paste.
 - c. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.

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Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, for easy removal.

- d. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- e. Chamfer exposed corners and edges as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- f. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.
- g. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is placed. Retighten forms and bracing before concrete placement as required to prevent mortar leaks and maintain proper alignment.

C. VAPOR BARRIER INSTALLATION

- a. General: See Section 07 2600 Under-Slab Vapor Retarder portion of these specifications. Following leveling and tamping of granular base for slabs on grade, place vapor barrier sheeting with longest dimension parallel with direction of pour.
- b. Lap joints 6 inches and seal vapor barrier joints with manufacturers' recommended mastic and pressure-sensitive tape.
- c. After placement of vapor barrier, cover with sand cushion and compact to depth as shown on drawings.

D. PLACING REINFORCEMENT

- a. Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports and as herein specified.
- b. Avoiding cutting or puncturing vapor barrier during reinforcement placement and concreting operations.
- c. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.
- d. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as approved by Architect.
- e. Place reinforcement to obtain at least minimum coverages for concrete protection.

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Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

- f. Construction Joints: Locate and install construction joints as indicated or, if not indicated, locate so as not to impair strength and appearance of the structure, as acceptable to Architect.
- g. Sawcut Joints: Where indicated on Drawings, sawcut joints to a depth of ½” and a width of 1/8”. Conduct sawcutting operations as soon as practicable after finish troweling of slab and as soon as concrete will support foot traffic and concrete saw. DO NOT ALLOW concrete to relieve itself at locations other than the sawcut locations.
- h. Provide keyways at least 1-1/2 inches deep in construction joints in walls and slabs and between walls and footings. Accepted bulkheads designed for this purpose may be used for slabs.
- i. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as otherwise indicated. Do not continue reinforcement through sides of strip placements.
- j. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.
- k. Joint filler and sealant materials are specified in Division 7 Sections of these specifications.

E. INSTALLATION OF EMBEDDED ITEMS

- a. General: Set and build into work anchorage devices and other embedded item required for other work that is attached to or supported by cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached thereto.
- b. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to obtain required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike-off templates or compacting-type screeds.

F. PREPARATION OF FORM SURFACES

- a. General: Coat contact surfaces of forms with an approved, nonresidual, low-VOC, form-coating compound before reinforcement is placed.
- b. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.

G. CONCRETE PLACEMENT

- a. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work.

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- b. General: Comply with ACI 304, "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete," and as herein specified.
- c. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete to avoid segregation at its final location.
- d. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.
- e. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI 309.
- f. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.
- g. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until the placing of a panel or section is completed.
- h. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.
- i. Bring slab surfaces to correct level with straight edge and strike off. Use bull floats or darbies to smooth surface, free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.
- j. Maintain reinforcing in proper position during concrete placement.
- k. Cold-Weather Placement: Comply with provisions of ACI 306 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
- l. When air temperature has fallen to or is expected to fall below 40 deg F (4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
- m. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
- n. Do not use calcium chloride, salt, and other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.

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- o. Hot-Weather Placement: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
- p. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 deg F (32 deg C). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water. Use of liquid nitrogen to cool concrete is Contractor's option.
- q. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
- r. Fog spray forms, reinforcing steel, and subgrade just before concrete is placed.

H. FINISH OF FORMED SURFACES

- a. Rough Form Finish: For formed concrete surfaces not exposed to view in the finish work or concealed by other construction. This is the concrete surface having texture imparted by form-facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.

I. MONOLITHIC SLAB FINISHES

- a. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view and slab surfaces to be covered with protection mats.
 - i. After floating, begin first trowel finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with surface leveled to tolerances of Ff 20 - Fl 17. Grind smooth surface defects that would telegraph through applied floor covering system.

J. NON-SLIP BROOM OR SALT FINISHES

- a. Apply nonslip broom and salt finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
 - i. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber-bristle broom perpendicular to main traffic route. Apply salt to surface, using hand broadcasting method, to provide a uniform textured pattern to concrete. Thoroughly wash surface free of salt no more than 24-48 hours after application. Coordinate required final finish with Architect before application.

K. CONCRETE CURING AND PROTECTION

- a. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply in

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accordance with manufacturer's instructions after screeding and bull floating, but before power floating and troweling.

- b. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
- c. Curing Methods: Perform curing of concrete by curing and sealing compound, by moist curing, by moisture-retaining cover curing, and by combinations thereof, as herein specified.
- d. Provide moisture curing by following methods:
 - 1. Keep concrete surface continuously wet by covering with water.
 - 2. Use continuous water-fog spray.
 - 3. Cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4-inch lap over adjacent absorptive covers.
- e. Provide curing and sealing compound to exposed exterior slabs, walks, curbs and interior slabs not scheduled to receive concrete stain as follows:
 - i. Apply specified curing and sealing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - j. Use membrane curing compounds that will not affect surfaces to be covered with finish materials applied directly to concrete.
 - k. Curing Formed Surfaces: Cure formed concrete surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
 - l. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, and other flat surfaces, by application of appropriate curing method.

L. REMOVAL OF FORMS

- a. General: Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form-removal operations, and provided curing and protection operations are maintained.

M. RE-USE OF FORMS

- a. Clean and repair surfaces of forms to be reused in work. Split, frayed, delaminated, or

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otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.

- b. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use "patched" forms for exposed concrete surfaces except as acceptable to Architect.

N. MISCELLANEOUS CONCRETE ITEMS

- a. Filling In: Fill in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.
- b. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- c. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings or as required by manufacturer of units. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.
- d. Reinforced Masonry: Provide concrete grout for reinforced masonry lintels and bond beams where indicated on drawings and as scheduled. Maintain accurate location of reinforcing steel during concrete placement.

O. CONCRETE SURFACE REPAIRS

- a. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to Architect.
- b. Cut out honeycomb, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts, down to solid concrete but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with specified bonding agent. Place patching mortar before bonding compound has dried.
- c. For exposed-to-view surfaces, blend white portland cement and standard portland cement so that, when dry, patching mortar will match color surrounding. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.
- d. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of Architect. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes, fill with dry-pack mortar, or precast cement cone plugs secured in place with bonding agent.

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- e. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.
- f. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct low and high areas as herein specified. Test unformed surfaces sloped to drain for trueness of slope and smoothness by using a template having required slope.
- g. Repair finished, unformed surfaces that contain defects that affect durability of concrete. Surface defects, as such, include crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, popouts, honeycomb, rock pockets, and other objectionable conditions.
- h. Correct high areas in unformed surfaces by grinding after concrete has cured at least 14 days.
- i. Correct low areas in unformed surfaces during or immediately after completion of surface finishing operations by cutting out low areas and replacing with patching compound. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used when acceptable to Architect.
- j. Repair defective areas, except random cracks and single holes not exceeding 1 inch in diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding compound. Mix patching concrete of same materials to provide concrete same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
- k. Repair isolated random cracks and single holes not over 1 inch in diameter by dry-pack method. Groove top of cracks and cut out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Mix dry-pack, consisting of one part portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Place dry-pack before bonding compound has dried. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for not less than 72 hours.
- l. Perform structural repairs with prior approval of Architect for method and procedure, using specified epoxy adhesive and mortar.
- m. Repair methods not specified above may be used, subject to acceptance of Architect.

P. QUALITY CONTROL TESTING DURING CONSTRUCTION

- a. General: The Contractor will employ a testing laboratory to perform tests and to submit test reports.
- b. Sampling and testing for quality control during placement of concrete may include the

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following, as directed by Architect.

- c. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
- d. Slump: ASTM C 143; one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.
- e. Concrete Temperature: Test hourly when air temperature is 40 deg F (4 deg C) and below, when 80 deg F (27 deg C) and above, and each time a set of compression test specimens is made.
- e. Compression Test Specimen: ASTM C 31; one set of 4 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory-cured test specimens except when field-cure test specimens are required.
- f. Compressive Strength Tests: ASTM C 39; one set for each day's pour exceeding 5 cu. yds. plus additional sets for each 50 cu. yds. more than the first 25 cu. yds. of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen retained in reserve for later testing if required.
- g. When frequency of testing will provide fewer than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.
- h. When total quantity of a given class of concrete is less than 50 cu. yds., Architect may waive strength test if adequate evidence of satisfactory strength is provided.
- i. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
- j. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive strength by more than 500 psi.
- k. Test results will be reported in writing to Architect, Structural Engineer, Ready-Mix Producer, and Contractor within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day tests and 28-day tests.
- l. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
- m. Additional Tests: The testing service will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Architect. Testing service may conduct tests

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to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

END OF SECTION

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SECTION 04 81 00 - UNIT MASONRY ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes unit masonry assemblies consisting of the following:
 - 1. Concrete masonry units (CMUs).
 - 2. Mortar and grout.
 - 3. Reinforcing steel.
 - 4. Masonry joint reinforcement.
 - 5. Ties and anchors.
 - 6. Embedded flashing.
 - 7. Miscellaneous masonry accessories.
- B. Related Sections include the following:
 - 1. Division 7 Section "Joint Sealants" for sealing control and expansion joints in unit masonry.
- C. Products installed, but not furnished, under this Section include the following:

1.3 DEFINITIONS

- A. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide unit masonry that develops indicated net-area compressive strengths as indicated on the drawings.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For the following:
 - 1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes, if any.
 - 2. Reinforcing Steel: Detail bending and placement of unit masonry reinforcing bars. Comply with ACI 315, "Details and Detailing of Concrete Reinforcement."
 - 3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.
- C. Qualification Data: For testing agency.

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- D. Material Certificates: Include statements of material properties indicating compliance with requirements including compliance with standards and type designations within standards. Provide for each type and size of the following:
1. Masonry units.
 - a. Include material test reports substantiating compliance with requirements.
 - b. For masonry units used in structural masonry, include data and calculations establishing average net-area compressive strength of units.
 2. Cementitious materials. Include brand, type, and name of manufacturer.
 3. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
 4. Grout mixes. Include description of type and proportions of ingredients.
 5. Reinforcing bars.
 6. Joint reinforcement.
 7. Anchors, ties, and metal accessories.
- E. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.
1. Include test reports, per ASTM C 780 for mortar mixes required to comply with property specification.
 2. Include test reports, per ASTM C 1019, for grout mixes required to comply with compressive strength requirement.
- F. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined according to Table 21-D in the International Building Code.
- G. Cold-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with cold-weather requirements.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1093 for testing indicated, as documented according to ASTM E 548.
- B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, through one source from a single manufacturer for each product required.
- C. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from a single manufacturer for each cementitious component and from one source or producer for each aggregate.
- D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

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1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.8 PROJECT CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
 - 1. Extend cover a minimum of **24 inches** down both sides and hold cover securely in place.
- B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least 3 days after building masonry walls or columns.
- C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
 - 1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 - 2. Protect sills, ledges, and projections from mortar droppings.
 - 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 - 4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in Section 2104.3 in the International Building Code.
 - 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is **40 deg F** and above and will remain so until masonry has dried, but not less than 7 days after completing cleaning.
- E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
 2. Products: Subject to compliance with requirements, provide one of the products specified.
 3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 MASONRY UNITS, GENERAL

- A. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to exceed tolerances and to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects, including dimensions that vary from specified dimensions by more than stated tolerances, will be exposed in the completed Work or will impair the quality of completed masonry.

2.3 CONCRETE MASONRY UNITS (CMUs)

- A. Shapes: Provide shapes indicated and as follows:
1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
 2. Provide square-edged shapes.
- B. Concrete Masonry Units: ASTM C 90.
1. Unit Compressive Strength: See structural drawings.
 2. Weight Classification: Lightweight Grade N-1.
 3. Size (Width): 8 inches nominal, manufactured to dimensions 3/8 inch less than nominal dimensions.
 4. Color: Shall be integrally colored, color as selected from manufacturer's standard color chart.

2.4 MASONRY LINTELS

- A. General: Provide masonry lintels complying with requirements below.
- B. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam concrete masonry units with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.
- C. Color: Integral color to match field units.

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2.5 MORTAR AND GROUT MATERIALS

- A. Portland Cement: ASTM C 150, Type II, except Type III may be used for cold-weather construction. Grout color to match concrete masonry units.
- B. Hydrated Lime: ASTM C 207 Type S.
- C. Portland Cement-Lime Mix: Packaged blend of portland cement complying with ASTM C 150, Type I or Type III, and hydrated lime complying with ASTM C 207, Type S.
- D. Masonry Cement: ASTM C 91.
- E. Mortar Cement: ASTM C 1329.
- F. Aggregate for Mortar: ASTM C 144.
 - 1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
 - 2. For joints less than **1/4 inch** thick, use aggregate graded with 100 percent passing the **No. 16** sieve.
- G. Aggregate for Grout: ASTM C 404.
- H. Cold-Weather Admixture: Non-chloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.
- I. Water: Potable.

2.6 REINFORCEMENT

- A. Uncoated Steel Reinforcing Bars: ASTM A 615/A 615M or ASTM A 996/A 996M, **Grade 60**
- B. Masonry Joint Reinforcement for Single-Wythe Masonry: Ladder type #9 with single pair of side rods. Hot-dip galvanized.

2.7 MISCELLANEOUS ANCHORS

- A. Unit Type Inserts in Concrete: Cast-iron or malleable-iron wedge-type inserts.
- B. Dovetail Slots in Concrete: Furnish dovetail slots with filler strips, of slot size indicated, fabricated from **0.034-inch**, galvanized steel sheet.
- C. Anchor Bolts: Headed or L-shaped steel bolts complying with **ASTM A 307, Grade A** with **ASTM A 563** hex nuts and, where indicated, flat washers; hot-dip galvanized to comply with ASTM A 153/A 153M, Class C; of dimensions indicated.
- D. Post-installed Anchors: Provide chemical or torque-controlled expansion anchors, with capability to sustain, without failure, a load equal to six times the load imposed when installed in solid or grouted unit masonry and equal to four times the load imposed when installed in

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concrete, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.

1. Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (5 microns) for Class SC 1 service condition (mild).

2.8 MISCELLANEOUS MASONRY ACCESSORIES

- A. Preformed Control-Joint Gaskets: Made from PVC, complying with ASTM D 2287 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated as shown on the drawings.
- B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells with loops for holding reinforcing bars in center of cells. Units formed from 0.142-inch steel wire, hot-dip galvanized after fabrication. Provide units with either two loops or four loops as needed for number of bars indicated.

2.9 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.
 1. Do not use calcium chloride in mortar or grout.
 2. Limit cementitious materials in mortar for exterior and reinforced masonry to portland cement and lime.
 3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
- B. Pre-blended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a pre-blended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C 270 Property Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.
 1. For masonry below grade or in contact with earth, use Type S.
 2. For reinforced masonry, use Type S.
- D. Grout for Unit Masonry: Comply with ASTM C 476.
 1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with Table 21-C in the International Building Code for dimensions of grout spaces and pour height.
 2. Provide grout with a slump of 8 to 11 inches as measured according to ASTM C 143/C 143M.
 3. Color to match concrete masonry units.
- E. Epoxy Pointing Mortar: Mix epoxy pointing mortar to comply with mortar manufacturer's written instructions.

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PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work.
 - 1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of work.
 - 2. Verify that foundations are within tolerances specified.
 - 3. Verify that reinforcing dowels are properly placed.
 - 4. Verify that underground conduit is placed so as not to interfere with required masonry reinforcement.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping and conduit connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Build chases and recesses to accommodate items specified in this and other Sections.
- B. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match the construction immediately adjacent to opening.
- C. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

3.3 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond. Do not use units with less than nominal 4-inch horizontal face dimensions at corners or jambs.
- C. Stopping and Resuming Work: Stop work by racking back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- E. Fill space between steel frames and masonry solidly with mortar, unless otherwise indicated.

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- F. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below and rod mortar or grout into core.
- G. Fill cores in hollow concrete masonry units with grout 24 inches under bearing plates, beams, lintels, posts, and similar items, unless otherwise indicated.

3.4 MORTAR BEDDING AND JOINTING

- A. Lay hollow concrete masonry units as follows:
 - 1. With webs fully bedded in mortar in all courses of piers, columns, and pilasters.
 - 2. With webs fully bedded in mortar in grouted masonry, including starting course on footings.
- B. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness, unless otherwise indicated.

3.5 MASONRY JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch on exterior side of walls. Lap reinforcement a minimum of 6 inches (150 mm).
 - 1. Space reinforcement not more than 16 inches o.c.
 - 2. Space reinforcement not more than 8 inches o.c. in foundation walls and parapet walls.
 - 3. Provide reinforcement not more than 8 inches above and below wall openings and extending 12 inches beyond openings.
 - a. Reinforcement above is in addition to continuous reinforcement.
- B. Interrupt joint reinforcement at control and expansion joints, unless otherwise indicated.
- C. Provide continuity at corners by using prefabricated L-shaped units.
- D. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets and other special conditions.

3.6 CONTROL AND EXPANSION JOINTS

- A. General: Install control and expansion joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.
- B. Form control joints in concrete masonry as follows:
 - 1. Install preformed control-joint gaskets designed to fit standard sash block.
 - 2. Install interlocking units designed for control joints. Install bond-breaker strips at joint. Keep head joints free and clear of mortar or rake out joint for application of sealant.

3.7 LINTELS

- A. Provide reinforced concrete unit masonry lintels where shown on drawings.
- B. Provide minimum bearing at each jamb, as shown on the drawings.

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3.8 REINFORCED UNIT MASONRY INSTALLATION

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
 - 1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
 - 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other temporary loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in Section 2104.5 in the Uniform Building Code and as shown on the drawings.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
 - 1. Comply with requirements in Section 2104.6 in the International Building Code for cleanouts and for grout placement, including minimum grout space and maximum pour height.
 - 2. Limit height of vertical grout pours to not more than 60 inches in height.

3.9 FIELD QUALITY CONTROL

- A. Inspectors: Owner will engage qualified independent inspectors to perform inspections and prepare reports. Allow inspectors access to scaffolding and work areas, as needed to perform inspections.
 - 1. Place grout only after inspectors have verified compliance of grout spaces and grades, sizes, and locations of reinforcement.
- B. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections indicated below and prepare test reports:
 - 1. Payment for these services will be made by Owner.
 - 2. Retesting of materials failing to comply with specified requirements shall be done at Contractor's expense.
- C. Testing Frequency: One set of tests for each 5000 sq. ft. of wall area or portion thereof.
- D. Concrete Masonry Unit Test: For each type of unit provided, per ASTM C 140.
- E. Mortar Test (Property Specification): For each mix provided, per ASTM C 780.
- F. Grout Test (Compressive Strength): For each mix provided, per ASTM C 1019.
- G. Prism Test: For each type of construction provided, per ASTM C 1314 at 7 days and at 28 days.

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3.10 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
 - 1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
 - 2. Protect adjacent existing masonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
 - 3. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
 - 4. Clean masonry with a proprietary acidic cleaner applied according to manufacturer's written instructions.
 - 5. Clean concrete masonry by cleaning method indicated in NCMA TEK 8-2A applicable to type of stain on exposed surfaces.

3.11 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

END OF SECTION

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SECTION 05 50 00 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Steel framing, stiffeners and supports for mechanical and electrical equipment.
 - 2. Steel framing and supports for applications where framing and supports are not specified in other Sections.
 - 3. Steel Pipe Bollards.
- B. Related Sections include the following:
 - 1. Division 3 Section "Cast-in-Place Concrete" for installing anchor bolts, steel pipe sleeves, wedge-type inserts and other items indicated to be cast into concrete.

1.3 SUBMITTALS

- A. Welding certificates.
- B. Qualification Data: For professional engineer.

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METALS, GENERAL

- A. See structural drawings for detailed description of work required for steel bar joist stiffening.
- B. Metal Surfaces, General: Provide materials with smooth, flat surfaces, unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

2.2 FERROUS METALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- B. Steel Pipe: ASTM A 53/A 53M, Extra Strong weight.

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2.3 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- B. Shop Primers: Provide primers that comply with Division 9 painting Sections.
- C. Zinc-Rich Primer: Complying with SSPC-Paint 20 or SSPC-Paint 29 and compatible with topcoat.
 - 1. Use primer with a VOC content of 3.5 lb/gal. or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Available Products:
 - a. Benjamin Moore & Co.; Epoxy Zinc-Rich Primer CM18/19.
 - b. Carboline Company; Carbozinc 621.
 - c. ICI Devco Coatings; Catha-Coat 313.
 - d. International Coatings Limited; Interzinc 315 Epoxy Zinc-Rich Primer.
 - e. PPG Architectural Finishes, Inc.; Aquapon Zinc-Rich Primer 97-670.
 - f. Sherwin-Williams Company (The); Corothane I GalvaPac Zinc Primer.
 - g. Tnemec Company, Inc.; Tneme-Zinc 90-97.
- D. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

2.4 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately **1/32 inch**, unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- B. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- C. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
 - 1. Where units are indicated to be cast into concrete, weld #4 rebar to both sides of embedded pipe to prevent pipe rotation after final installation. See detail on drawings.

2.5 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: See Structural Drawings for steel stiffener/support requirements.

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2.6 CONCRETE FILLED STEEL BOLLARDS

- A. Fabricate concrete filled steel bollards from Extra Strong Steel Pipe, 0.432-inch wall-thickness.
- B. Provide anchors for embedding units in concrete as detailed on the drawings.

2.7 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Prime and paint in accordance with these specifications.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

3.2 INSTALLING PIPE BOLLARDS

- A. Anchor bollards in concrete.
- B. Anchor bollards in place with concrete footings. Center and align bollards in holes 3 inches above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.
- C. Fill bollards solidly with concrete, mounding top surface to shed water.

END OF SECTION 05500

SECTION 07 54 23 - TPO THERMOPLASTIC SINGLE-PLY ROOFING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. TPO Thermoplastic Single-Ply Roofing.
- B. TPO Thermoplastic Walking Pads.
- C. Membrane Flashings.
- D. Metal Flashings.
- E. Roof Insulation.

1.2 RELATED DIVISIONS

- A. Division 22 - Plumbing
- B. Division 23 – Heating, Ventilating and Air-Conditioning (HVAC)

1.3 REFERENCES

- A. American Society of Civil Engineers (ASCE) - ASCE 7 - Minimum Design Loads for Buildings and Other Structures, Current Revision.
- B. ANSI/SPRI WD-1 "Wind Design Standard for Roofing Assemblies".
- C. ASTM International (ASTM):
 - 1. ASTM C 578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
 - 2. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
 - 3. ASTM D 1079 - Standard Terminology Relating to Roofing, Waterproofing, and Bituminous Materials.
 - 4. ASTM D 6878 - Standard Specification for Thermoplastic Polyolefin Based Sheet Roofing.
 - 5. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials.
- D. Factory Mutual (FM Global):
 - 1. Approval Guide.
 - a. Factory Mutual Standard 4470 - Approval Standard for Class 1 Roof Covers.
 - b. Loss Prevention Data Sheets 1-28, 1-29.
- E. International Code Council (ICC):
 - 1. International Building Code (IBC).
- F. National Roofing Contractors Association (NRCA) - Low Slope Roofing and Waterproofing Manual, Current Edition.

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- G. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) - Architectural Sheet Metal Manual.
- H. Underwriters Laboratories (UL):
 - 1. TGFU R1306 - "Roofing Systems and Materials Guide".
 - 2. UL-790 - Standard Test Method for Fire Tests of Roof Coverings.
- I. ANSI/ASHRAE/IESNA Standard 9.1 (2007): Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.4 DESIGN CRITERIA

- A. Wind Uplift Performance:
 - 1. Roof system is designed to withstand wind uplift forces as calculated using the current revision of ASCE-7.
 - 2. Roof system is designed to achieve a minimum 55 mph speed warranty.
- B. Fire Resistance Performance:
 - 1. Roof system will achieve a UL Class C rating when tested in accordance with UL-790.
- C. Drainage: Provide a roof system with positive drainage where all standing water dissipates within 48 hours after precipitation ends.
- D. Building Codes:
 - 1. Roof system will meet the requirements of all federal, state and local code bodies having jurisdiction.

1.5 SUBMITTALS

- A. Submit under provisions of section entitled "SUBMISSIONS".
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Detail Drawings:
 - 1. Submit approved plan, section, elevation or isometric drawings which detail the appropriate methods for all flashing conditions found on the project.
 - 2. Coordinate approved drawings with locations found on the Contract Drawings.
- D. Verification Samples: For each finish product specified, two samples, minimum size 4 inches (100 mm) square representing actual product, color, and patterns.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: All primary products specified in this section will be supplied by a single manufacturer with a minimum of twenty (20) years experience.
- B. Installer Qualifications:
 - 1. All products listed in this section are to be installed by a single installer with a minimum of five (5) years demonstrated experience in installing products of the same

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- type and scope as specified.
- 2. Installer must be capable of extending the Manufacturer's Labor and Materials guarantee.
- 3. Installer must be capable of extending the Manufacturer's No Dollar Limit guarantee.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Store and dispose of hazardous materials, and materials contaminated by hazardous materials, in accordance with requirements of local authorities having jurisdiction.
- C. Safety Data Sheets (SDS) must be on location at all times during the transportation, storage and application of materials.
- D. When loading materials onto the roof, the Roofing Applicator must comply with the requirements of the building owner to prevent overloading and possible disturbance to the building structure.

1.8 PROJECT CONDITIONS

- A. Proceed with roofing work only when weather conditions are in compliance with the manufacturer's recommended limitations, and when conditions will permit the work to proceed in accordance with the manufacturer's requirements and recommendations.
- B. Proceed with work so new roofing materials are not subject to construction traffic. When necessary, new roof sections shall be protected and inspected upon completion for possible damage.
- C. Provide protection, such as 3/4 inch thick plywood, for all roof areas exposed to traffic during construction. Plywood must be smooth and free of fasteners and splinters.
- D. The surface on which the insulation or roofing membrane is to be applied shall be clean, smooth, dry, and free of projections or contaminants that would prevent proper application of or be incompatible with the new installation, such as fins, sharp edges, foreign materials, oil and grease.
- E. New roofing shall be complete and weather tight at the end of the work day.
- F. Contaminants such as grease, fats and oils shall not be allowed to come in direct contact with the roofing membrane.

1.9 WARRANTY

- A. At project closeout, provide to Owner or Owners Representative an executed copy of the manufacturer's Total System warranty, outlining its terms, conditions, and exclusions from coverage.
 - 1. Duration: 20 Years.
 - 2. Coverage to be extended to include accidental punctures in accordance with terms stated in the Warranty document.
 - 3. Coverage to be extended to include hail damage in accordance with terms stated in the Warranty document.
 - 4. Coverage to be extended to include roof edge metal water tightness in accordance

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with terms stated in the Warranty document.

- B. When positioning membrane sheets, exercise care to locate all field splices away from low spots and out of drain sumps. All field splices should be shingled to prevent bucking of water.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Carlisle Roofing Systems, Inc: www.carlisle-syntec.com
- A. Firestone Building Products, LLC: www.firestonebpco.com
- B. GAF: www.gaf.com
- C. Johns-Manville: www.jm.com

2.2 SCOPE / APPLICATION

- A. Roof System: Provide a waterproof roof system, capable of withstanding uplift forces as specified in the Design Criteria article of this section.
 - 1. Membrane Attachment: Fully Adhered.
- B. Base Flashing: Provide a waterproof, fully adhered base flashing system at all penetrations, plane transitions and terminations.
- C. Insulation: Provide a roof insulation system beneath the finish membrane.

2.3 INSULATION

- A. SecurShield Polyiso: Rigid board with coated glass fiber mat facers (CGF) on both sides, meeting or exceeding the requirements of ASTM C 1289, Type II, Class 2.
 - 1. Compressive Strength: Grade 2, 20 psi (138 kPa).
- B. SecurShield HD Polyiso Cover board: Rigid board with coated glass fiber mat facers (CGF) on both sides, meeting or exceeding the requirements of ASTM C 1289, Type II, Class 4, Grade 1.
 - 1. Compressive Strength: 80 psi min. (551 kPa).
 - 2. Board Thickness: 1/2 inch (13 mm).

2.4 INSULATION ADHESIVE

- A. Flexible FAST Adhesive: A spray or extruded applied, two-component polyurethane, low-rise expanding foam adhesive used for attaching approved insulations to compatible substrates (concrete, cellular lightweight insulating concrete, gypsum, cementitious wood fiber, wood or steel) or existing smooth or gravel surfaced BUR, modified bitumen or cap sheets.

2.5 THERMOPLASTIC POLYOLEFIN (TPO) MEMBRANE

- A. Sure-Weld EXTRA Membrane:
 - 1. Color: White.
 - 2. Membrane Thickness: 80 mil nominal.

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- a. Thickness over Scrim: 0.034 inches (0.86 mm) +/-10 percent.
- b. Breaking Strength (ASTM D 751): 350 lbf/in (1.6 kN/m) minimum.
- c. Tear Resistance (ASTM D 751): 55 lbf/in (245 N/m) minimum.
- d. Elongation (ASTM D 751): 25 percent.

B. Thermoplastic Walkway Pads:

1. Shall be equal to "Sure-Weld" TPO Walkway Rolls as mfd. by Carlisle Syntec Systems.
2. Color: White
3. Thickness: 80-mil at bottom of tread, 80-mil at yellow welding edge; 170-mil overall.
4. Roll Width: 34"

2.6 FLASHING ACCESSORIES

- A. Inside Corners: Pre-molded corner flashing for inside corners. 60 mil thickness. Color to match membrane.
- B. Outside Corners: Injection molded corner used for flashing outside corners. 60 mil thickness. Color to match membrane.
- C. TPO Curb Wrap Corners: Pre-fabricated corner flashings made from 60 mil thick reinforced Sure-Weld membrane. 6 inch (152 mm) wide base flange and a 12 inch (305 mm) overall height. Color to match membrane.
- D. Molded Pipe Seals: A pre-molded flashing and clamping ring used for pipe penetrations.. Color to match membrane..
- E. Pressure-Sensitive Cover Strip: A nominal 6 inch (152 mm) wide by 40 mil thick non-reinforced TPO membrane laminated to nominal 35-mil thick cured synthetic rubber pressure-sensitive adhesive. Used in conjunction with TPO Primer to strip in flat metal flanges (i.e., drip edges or rows of fasteners and plates). Color to match membrane.
- F. Sure-Weld Heat Weldable 34" wide Walkway Rolls, nominal 180 mils thick, gray in color.
- G. Non-Reinforced Flashing: Non-reinforced TPO flashing is a 60-mil thick non-reinforced TPO based membrane used for detail work where the use of pre-molded or pre-fabricated accessories are not feasible. Color – White.

2.7 CLEANERS, PRIMERS, ADHESIVES AND SEALANTS

- A. CAV-GRIP III Low-VOC Aerosol Contact Adhesive/Primer: a low-VOC, methylene chloride-free adhesive that can be used for a variety of applications including: Bonding Sure-Weld membrane to various surfaces, priming unexposed asphalt prior to applying Flexible FAST Adhesive, adhering Sure-Weld TPO membrane, horizontally, for the field of the roof, and for adhering Sure-Weld FleeceBACK and Sure-Weld TPO membrane to vertical walls. Coverage rate is approximately 2,000-2,500 sq. ft. per 40 lb cylinder and 4,000-5,000 sq. ft. per 85 lb cylinder as a primer, in a single-sided application; 750 sq. ft. per 40 lb cylinder and 1,500 sq. ft. per 85 lb cylinder as an adhesive for vertical walls, in a double-sided application; 1,000 sq. ft. per 40 lb cylinder and 2,000 sq. ft. per 85 lb cylinder as an adhesive, horizontally, for the field of the roof, in a double-sided application.
- B. Cut Edge Sealant: A medium solids content, free flowing polymeric material designed for

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sealing cut edges (exposed fabric) of Sure-Weld reinforced membrane.

- C. Water Cut-Off Mastic: A one-component, low viscosity, self wetting, Butyl blend mastic used as a compression sealing agent between membrane and applicable substrates.
- D. TPO Primer: Solvent-based product designed to prepare TPO membrane for improved adhesion to TPO surfaces prior to the application of pressure-sensitive products and sealant pockets.
- E. Universal Single-Ply Sealant: A 100 percent solids, solvent free, VOC free, one-part polyether sealant that provides a weather tight seal to a variety of building materials. It is used for general caulking such as above termination bars and metal counter flashings and at scupper details.. Available in white only.
- F. Thermoplastic One-Part Sealant: Single component, moisture curing, elastomeric polyether sealant that is compatible with Carlisle's Thermoplastic membranes.
- G. Carlisle Weathered Membrane Cleaner: Clear, solvent-based cleaner. Use to loosen and remove contaminants from the surface of exposed membrane.
- H. CCW 702 WB - a high-tack, water-based contact adhesive for promoting adhesion of Carlisle air/vapor barrier membranes and an approved substrate (i.e., concrete, Dens-Deck Prime and Securock). Apply by roller, brush or spray with an application rate of approximately 200 sq. ft. per gallon. ** NOTE TO SPECIFIER ** Retain the next article only if Sure Weld FleeceBACK Hot Mopped System is specified or insulation is asphalt adhered.

2.8 FASTENING COMPONENTS

- A. InsulFast Fasteners: Threaded, #12 fastener with a #3 Phillips head used with 3 inch (76mm) diameter Insulation Plates. For insulation attachment into steel or wood decks.
- B. Pre-Assembled ASAP Fasteners: InsulFast Fastener and pre-assembled 3 inch (76mm) diameter Plastic Insulation Plate for insulation attachment on adhered and mechanically-fastened roofing systems.
- C. Base Sheet Fasteners And Plates as recommended by manufacturer of roofing products.
- D. Piranha Plates: A 2 3/8 inch (60mm) diameter metal barbed fastening plate used with Carlisle HP-X, CD-10 or HD 14-10 Fasteners for membrane securement. This plate can be used for insulation securement.
- E. Insulation Fastening Plates: A nominal 3 inch (76mm) diameter metal plate used for insulation attachment in conjunction with the appropriate fastener as recommended by roofing manufacturer.

2.9 EDGINGS AND TERMINATIONS

- A. SecurEdge Coping: An anchor cleat with pre-slotted holes, a concealed joint cover, and 10 or 12 foot sections of coping cap. Kynar 500 finish in color to match existing.
- B. Sure-Seal Termination Bar: 1 inch (13 mm) wide, .098 inch (2.5 mm) thick extruded aluminum bar pre-punched 6 inches (152 mm) on center with sealant ledge to support Lap

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Sealant.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- C. Do not commence work until all other work trades have completed jobs that require them to traverse the deck on foot or with equipment.

3.3 INSULATION - SYSTEM DESIGN

- A. Base Layer:
 - 1. Type: 20psi “Insulbase” polyisocyanurate board, 4’x4’.
 - 2. Thickness: 1-1/2 inches
 - 3. Attachment Method: Mechanically fastened
- B. Top Layer:
 - 1. Type: “Secureshield” HD 4’x4’ boards
 - 2. Thickness: 1/2"inch
 - 3. Attachment Method: Adhered with “Fast” beads spaced 12” OC in the field and 6” OC along the perimeter.
- C. Tapered System:
 - 1. Type: Polyisocyanurate Boards
 - 2. Cricket Slope: 1/4 “ per foot.
 - 3. Attachment Method: As recommended by manufacturer.

3.4 INSULATION PLACEMENT

- A. Secure insulation to the substrate with the required mechanical fasteners or insulation adhesive in accordance with the manufacturer's current application guidelines.
- B. Do not install wet, damaged or warped insulation boards.
- C. Stagger joints in one direction unless joints are to be taped. Install insulation boards snug. Gaps between board joints shall not exceed 1/4 inch (6 mm). Fill all gaps in excess of 1/4 inch (6 mm) with same insulation material.
- D. Wood nailers must be at least 3 1/2 inches (89 mm) wide or 1 inch (25 mm) wider than adjacent metal flange. Thickness must equal that of insulation but not less than 1 inch (25 mm) thickness.

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- E. Miter and fill the edges of the insulation boards at ridges, valleys and other changes in plane to prevent open joints or irregular surfaces. Avoid breaking or crushing of the insulation at the corners.
- F. Do not install any more insulation than will be completely waterproofed each day.

3.5 INSULATION ATTACHMENT

- A. Securely attach insulation to the roof deck for Adhered Roofing Systems. Attachment must have been successfully tested to meet or exceed the calculated uplift pressure required by the International Building Code (ASCE-7) or ANSI/SPRI WD-1.
- B. Enhance the perimeter and corner areas in accordance with the International Building Code (ASCE-7) or ANSI/SPRI WD-1.
- C. Install insulation layers, maximum 4 feet by 4 feet (1220 mm by 1220 mm), applied with FAST adhesive, or a maximum 4 feet by 8 feet (1220 mm by 2438 mm), applied with Flexible FAST Adhesive, coverage rate as necessary to achieve the specified attachment and uplift rating. Press each board firmly into place after adhesive develops strings when touched, typically 1-1/2 to 2 minutes after adhesive was applied, and roll with a weighted roller. Add temporary weight and use relief cuts to ensure boards are well adhered. Stagger the joints of additional layers by a minimum of 6 inches (152 mm).

3.6 MEMBRANE PLACEMENT AND ATTACHMENT (Sure-Weld Fully Adhered)

- A. Position Sure-Weld membrane over the acceptable substrate. Fold membrane sheet back lengthwise so half the underside of the membrane is exposed.
- B. Apply approved Bonding Adhesive in accordance with the manufacturer's published instructions, to the exposed underside of the membrane and the corresponding substrate area. Do not apply Bonding Adhesive along the splice edge of the membrane to be hot air welded over the adjoining sheet. Allow the adhesive to dry until it is tacky but will not string or stick to a dry finger touch.
 - 1. Roll the coated membrane into the coated substrate while avoiding wrinkles. Brush down the bonded section of the membrane sheet immediately after rolling the membrane into the adhesive with a soft bristle push broom to achieve maximum contact.
 - 2. Fold back the unbonded half of the sheet lengthwise and repeat the bonding procedures.
- C. Position adjoining sheets to allow a minimum overlap of 2 inches.
- D. APEEL Protective Film should be removed from within areas that are to be heat-welded together. In areas that do not require heat welding, the APEEL Protective Film can be left in place for up to 90 days.
- E. Hot-air weld the Sure-Weld membrane sheets using the Automatic Hot Air Welding Machine or Hot Air Hand Welder in accordance with the manufacturer's hot air welding procedures. Carlisle recommends a test weld sample be made from a piece of scrap TPO to eliminate the need to remove a section from a completed seam. At all splice intersections, roll the seam with a silicone roller to ensure a continuous hot air welded seam.

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- F. Continue to install adjoining membrane sheets in the same manner, overlapping edges a minimum of 2 inches and complete the bonding procedures as stated previously.

3.7 SEAM WELDING

- A. APEEL Protective Film should be removed from within areas that are to be heat-welded together. In areas that do not require heat welding, the APEEL Protective Film can be left in place for up to 90 days.
- B. Hot-air weld membrane using an Automatic Hot Air Welding Machine or Hot Air Hand Welder in accordance with the manufacturer's current guidelines. At all splice intersections, roll the seam with a silicone roller to ensure a continuous hot air welded seam.
- C. Overlay all splice intersections with Sure-Weld T-Joint Cover.
- D. Probe all seams once the hot air welds have thoroughly cooled (approximately 30 minutes).
- E. Repair all seam deficiencies the same day they are discovered.
- F. Apply Cut Edge Sealant on all cut edges of reinforced membrane (where the scrim reinforcement is exposed) after seam probing is complete. Cut Edge Sealant is not required on vertical splices.

3.8 WALKWAY PADS

- A. See drawings for extent of walkway pads to be installed.
- B. Use membrane cleaner approved by pad manufacturer to prepare the existing membrane to be welded to the walkway material.
- C. Position walkway material; cut walkway rolls into maximum 10' lengths and position with a minimum 1" gap between adjacent pieces to allow for water drainage. Cut walkway pad so a 4" minimum gap is created over any existing membrane field splices.
- D. Use an automated welder and weld all four sides of the walkway to the membrane.
- E. Clean all walkway pads following installation.

3.9 FLASHING

- A. Flashing of parapets, curbs, expansion joints and other parts of the roof must be performed using Sure-Weld reinforced membrane or prefabricated accessories. Sure-Weld non-reinforced membrane may be used for flashing pipe penetrations, Sealant Pockets, and scuppers, as well as inside and outside corners, when the use of pre-molded or prefabricated accessories is not feasible.
- B. Follow manufacturer's typical flashing procedures for all wall, curb, and penetration flashing including metal edging/coping and roof drain applications.
- C. APEEL Protective Film should be removed and discarded after the completion of the roof system installation.

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3.10 DAILY SEALS

- A. On phased roofing, when the completion of flashings and terminations is not achieved by the end of the work day, a daily seal must be performed to temporarily close the membrane to prevent water infiltration.

3.11 CLEAN UP

- A. Perform daily clean-up to collect all wrappings, empty containers, paper, and other debris from the project site. Upon completion, all debris must be disposed of in a legally acceptable manner.
- B. Prior to the manufacturer's inspection for warranty, the applicator must perform a pre-inspection to review all work and to verify all flashing has been completed as well as the application of all caulking.

3.12 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

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SECTION 09 51 00 - ACOUSTICAL CEILINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Acoustical ceiling tiles.
- B. Metal Suspension System.

1.2 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM C423: Sound Absorption by Reverberation Room Method.
 - 2. ASTM C635: Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.
 - 3. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 4. ASTM E1264: Standard Classification for Acoustical Ceiling Products.

1.3 SUBMITTALS

- A. Submit under provisions of Section 01 30 00 - Administrative Requirements.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Test Reports: Upon request submit certified test reports from recognized test laboratories.
- D. Certificates: Submit manufacturer's certificate that products meet or exceed specified requirements.
- E. Shop Drawings: Submit shop drawings in detail of all work in scale to indicate size, location and attachment methods required for the installation of the required work.
- F. Verification Samples: Submit samples or portions of full size units showing jointing where such exists and methods of internal fastening as well as all other detailing required.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Minimum 2 year experience installing projects of similar size and complexity.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver material in the manufacturer's original, unopened, undamaged containers with identification labels intact.

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- B. Provide labels indicating brand name, source of procurement, style, size and thickness.
- C. Storage and Protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.
- D. Handling: Handle materials to avoid damage.

1.6 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

1.7 SEQUENCING

- A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

1.8 WARRANTY

- A. Warranty Period: One year.
 - 1. Manufacturer's warranty that the materials furnished hereunder will be free of manufacturing defects for a period of one year.

1.9 EXTRA MATERIALS

- A. Extra Materials: Provide 10 percent (10%) for use by owner in building maintenance and repair.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer:
 - 1. USG: www.usg.com
 - 2. Armstrong World Industries, Inc.: www.armstrongceilings.com
 - 3. Certaineed Corporation: www.certainteed.com

2.2 ACOUSTICAL CEILING TILES

- A. Material for use in all ceilings:
 - 1. Painted mineral-fiber, ASTM E1264, CLASS A, 5/8" thickness, square edge.

2.3 SUSPENSION SYSTEMS

- 1. ASTM C635, die-cut and interlocking components, with stabilizer bars clips, splices, perimeter moldings, and hold down clips as required.

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2. ASTM C636 – Standard specification for installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.
3. ASTM E84 – Standard Method for Surface Burning Characteristics of Building Materials.
4. ASTM E580 – Standard Practice for Application of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions.
5. CISCA Ceilings & Interior Systems Construction Association:
 - a. Ceiling Systems Handbook
 - b. Seismic Construction Handbook
 - i. Comply with ASTM C636 and ASTM E580 (including approved alternative methods).
6. Structural Classification: Heavy Duty
7. Tee Profile: 15/16”
8. Tee Height: 1.64”
9. Grid Module: As shown on drawings.
10. Fire Rating: Firecode
11. Finish: Standard White
12. Seismic Criteria: Seismic Design Category A as defined by the International Building Code.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Upon receiving and prior to the installation of the interior finish materials, the installing contractor shall completely read all of the manufacturer's instructions for storage, job conditions and the installation recommendations, and see that they are strictly complied with.
- B. Work shall not begin until the space is fully enclosed and glazed.
- C. All wet work is to be completed and dried out to the satisfaction of the architect.
- D. Temperature shall be at least 65 degrees F. during the installation and thereafter.
- E. The installation contractor shall be responsible for the examination of all of the conditions and recommendations as set forth and shall not proceed until satisfactory conditions have been met.

3.2 INSTALLATION

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- A. Installation shall be in strict accordance with the manufacturer's written recommendations, project specifications and the contract drawings. Installation shall be performed by trained crews under the direction of a trained foreman. Finished appearance in all cases shall be in exact conformance with the contract documents.
- B. Suspension cables should be securely anchored to structural bar joists. Avoid damaging existing blanket thermal insulation located at bottom of bar joists. Repair or replace any such damaged or removed existing insulation to the satisfaction of the Architect.
- C. Ceiling subcontractor shall fabricate and install "tents" to be installed over all luminaires located in main circulation Corridors to provide fire protection above Corridor ceilings. "Tents" to be fabricated from panels of Class A mineral fiber tiles.

3.3 CLEANING

- A. Clean exposed surfaces of ceiling panels to comply with manufacturer's instructions for cleaning.
- B. Remove and replace panels and tiles which cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

3.4 PROTECTION

- A. Protect installed work from damage due to subsequent construction activity, including temperature and humidity limitations and dust control, so that the work will be without damage and deterioration at the time of acceptance by the Owner.

END OF SECTION

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SECTION 09 90 00 - PAINTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Paint surface preparation.

1.2 REFERENCES

- A. Material Safety Data Sheets / Environmental Data Sheets: Per manufacturer's MSDS/EDS for specific VOCs (calculated per 40 CFR 59.406). VOCs may vary by base and sheen.

1.3 SUBMITTALS

- A. Submit under provisions of Section 01 30 00 - Administrative Requirements.
- B. Product Data Including:
 - 1. Product characteristics.
 - 2. Surface preparation instructions and recommendations.
 - 3. Primer requirements and finish specification.
 - 4. Storage and handling requirements and recommendations.
 - 5. Application methods.
 - 6. Cautions for storage, handling and installation.
- C. Selection Samples: Submit a complete set of color chips that represent the full range of manufacturer's products, colors and sheens available.
- D. Verification Samples: For each finish product specified, submit samples that represent actual product, color, and sheen.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.
- B. Paint exposed surfaces. If a color of finish, or a surface is not specifically mentioned, Architect will select from standard products, colors and sheens available.
- C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels unless indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver manufacturer's unopened containers to the work site. Packaging shall bear the manufacturer's name, label, and the following list of information.
 - 1. Product name, and type (description).
 - 2. Application and use instructions.
 - 3. Surface preparation.
 - 4. VOC content.
 - 5. Environmental handling.

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6. Batch date.
 7. Color number.
- B. Storage: Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.
- C. Store materials in an area that is within the acceptable temperature range, per manufacturer's instructions. Protect from freezing.
- D. Handling: Maintain a clean, dry storage area, to prevent contamination or damage to the coatings.

1.6 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

1.7 EXTRA MATERIALS

- A. Furnish Owner with an additional one percent of each material and color, but not less than 1 gal (3.8 l) or 1 case, as appropriate.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers:
1. Sherwin-Williams: www.swspecs.com.
 2. Benjamin-Moore: www.benjaminmoore.com
 3. PPG Paints: www.ppgpaints.com
 4. Dunn-Edwards: www.dunnedwards.com

2.2 APPLICATIONS/SCOPE

- A. Interior Paint and Coating Commercial Systems:
1. Drywall: Drywall board, Gypsum board.
- B. Exterior Paint and Coating Commercial Systems

2.3 PAINT MATERIALS - GENERAL

- A. Paints and Coatings:
1. Unless otherwise indicated, provide factory-mixed coatings. When required, mix coatings to correct consistency in accordance with manufacturer's instructions before application. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.
- B. Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.
- C. Colors: As selected by Architect.
- D. Drywall: Walls, Ceilings, Gypsum Board and similar items.

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1. Latex Systems:
 - a. Eg-Shel / Satin Finish:
 - 1) 1st Coat: S-W ProMar 200 Zero VOC Interior Latex Primer, B28W2600 (4 mils wet, 1.5 mils dry).
 - 2) 2nd Coat: S-W ProMar 200 Zero VOC Latex Eg-Shel, B20-2600 Series.
 - 3) 3rd Coat: S-W ProMar 200 HP Zero VOC Latex Eg-Shel, B20-2600 Series (4 mils wet, 1.7 mils dry per coat).
- E. Non-Factory Painted Metals:
 1. Waterbased Systems:
 - a. 1st Coat: S-W Pro Industrial Pro-Cryl Universal Prime B66-1310 Series (5.0-10.0 mils wet, 1.8-3.6 mils dry)
 - b. 2nd Coat: S-W Pro Industrial Waterbased Acrolon 100 Gloss, B65-720 Series
 - c. 3rd Coat: S-W Pro Industrial Waterbased Acrolon 100 Gloss, B65-720 Series (4.0-8.0 mils wet, 1.8-3.6 mils dry)

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared; notify Architect of unsatisfactory conditions before proceeding. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- B. Proceed with work only after conditions have been corrected and approved by all parties, otherwise application of coatings will be considered as an acceptance of surface conditions.
- C. Previously Painted Surfaces: Verify that existing painted surfaces do not contain lead based paints, notify Architect immediately if lead based paints are encountered.

3.2 SURFACE PREPARATION

- A. General: Surfaces shall be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.
 1. Prior to attempting to remove mildew, it is recommended to test any cleaner on a small, inconspicuous area prior to use. Bleach and bleaching type cleaners may damage or discolor existing paint films. Bleach alternative cleaning solutions are advised.
 2. Remove mildew before painting by washing with a solution of 1 part liquid household bleach and 3 parts of warm water. Apply solution and scrub the mildewed area. Allow solution to remain on the surface for 10 minutes. Rinse thoroughly with clean water and allow surface to dry before painting. Wear protective glasses or goggles, waterproof gloves, and protective clothing. Quickly wash off any of the mixture that comes in contact with your skin. Do not add detergents or ammonia to the bleach/water solution.
 3. Remove items including but not limited to thermostats, electrical outlets, switch covers and similar items prior to painting. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.
- B. Drywall - Interior: Must be clean and dry. All screw heads must be set and spackled. Joints must be taped and covered with a joint compound. Spackled screw heads and tape joints must be sanded smooth and all dust removed prior to painting.

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- C. Exterior Metals: Must be clean and dry. Do not paint materials that are factory painted. Metals that are not factory painted shall be smoothed out using industry standard abrasive products. Prime and paint as indicated above.

3.3 INSTALLATION

- A. Apply all coatings and materials with the manufacturer's specifications in mind. Mix and thin coatings according to manufacturer's recommendations.
- B. Do not apply to wet or damp surfaces.
- C. Apply coatings using methods recommended by manufacturer.
- D. Uniformly apply coatings without runs, drips, or sags, without brush marks, and with consistent sheen.
- E. Apply coatings at spreading rate required to achieve the manufacturers recommended dry film thickness.
- F. Regardless of number of coats specified, apply as many coats as necessary for complete hide, and uniform appearance.

3.4 PROTECTION

- A. Protect finished coatings from damage until completion of project.
- B. Touch-up damaged coatings after substantial completion, following manufacturer's recommendation for touch up or repair of damaged coatings. Repair any defects that will hinder the performance of the coatings.

END OF SECTION

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SECTION 32 31 19 – ORNAMENTAL STEEL FENCE

PART 1 - GENERAL

1.01 WORK INCLUDED

The contractor shall provide all labor, materials and appurtenances necessary for installation of the welded ornamental steel fence system shown on the drawings.

1.02 RELATED WORK

A. Section 03 30 00 CAST-IN-PLACE CONCRETE

The manufacturer shall supply a total fence system of Montage II “Majestic” 3 RAIL as manufactured by Ameristar Fence; 1555 N. Mingo, Tulsa, OK, 74116. The system shall include all components (i.e., panels, posts, gates and hardware) required.

1.04 QUALITY ASSURANCE

The contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.

1.05 REFERENCES

- ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
- ASTM B117 - Practice for Operating Salt-Spray (Fog) Apparatus.
- ASTM D523 - Test Method for Specular Gloss.
- ASTM D714 - Test Method for Evaluating Degree of Blistering in Paint.
- ASTM D822 - Practice for Conducting Tests on Paint and Related Coatings and Materials using Filtered Open-Flame Carbon-Arc Light and Water Exposure Apparatus.
- ASTM D1654 - Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.
- ASTM D2244 - Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.
- ASTM D2794 - Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
- ASTM D3359 - Test Method for Measuring Adhesion by Tape Test.
- ASTM F2408 – Ornamental Fences Employing Galvanized Steel Tubular Pickets.

1.06 SUBMITTALS

Submit manufacturer’s literature prior to installation for confirmation of system as well as for installation requirements.

1.07 PRODUCT HANDLING AND STORAGE

Upon receipt at the job site, all materials shall be checked to ensure that no damage occurred during shipping or handling. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and to protect against damage, weather, vandalism and theft.

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1.08 PRODUCT WARRANTY

A. All structural fence components (i.e. rails, pickets, and posts) shall be warranted within specified limitations, by the manufacturer for a period of 20 years from date of original purchase. Warranty shall cover any defects in material finish, including cracking, peeling, chipping, blistering or corroding.

PART 2 - MATERIALS

2.01 MANUFACTURER

The fence system shall conform to Montage II® *Majestic 3 RAIL* design, extended picket bottom rail treatment, style manufactured by Ameristar Fence Products, Inc., in Tulsa, Oklahoma.

2.02 MATERIAL

A. Steel material for fence panels and posts shall conform to the requirements of ASTM A653/A653M, with a minimum yield strength of 45,000 psi (310 MPa) and a minimum zinc (hot-dip galvanized) coating weight of 0.90 oz/ft² (276 g/m²), Coating Designation G-90.

B. Material for pickets shall be 1" square x 14 Ga. tubing. The rails shall be steel channel, 1.75" x 1.75" x .105". Picket holes in the rail shall be spaced 4.715" o.c. Fence posts and gate posts shall meet the minimum size requirements of Table 1.

2.03 FABRICATION

A. Pickets, rails and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets.

B. Pickets shall be inserted into the pre-punched holes in the rails and shall be aligned to standard spacing using a specially calibrated alignment fixture. The aligned pickets and rails shall be joined at each picket-to-rail intersection by Ameristar's proprietary fusion welding process, thus completing the rigid panel assembly (Note: The process produces a virtually seamless, spatter-free good-neighbor appearance, equally attractive from either side of the panel).

C. The manufactured panels and posts shall be subjected to an inline electrodeposition coating (E-Coat) process consisting of a multi-stage pretreatment/wash, followed by a duplex application of an epoxy primer and an acrylic topcoat. The minimum cumulative coating thickness of epoxy and acrylic shall be 2 mils (0.058 mm). The color shall be Black. The coated panels and posts shall be capable of meeting the performance requirements for each quality characteristic shown in Table 2 (Note: The requirements in Table 2 meet or exceed the coating performance criteria of ASTM F2408).

D. The manufactured fence system shall be capable of meeting the vertical load, horizontal load, and infill performance requirements for Industrial weight fences under ASTM F2408.

E. Swing gates shall be fabricated using 1.75" x 14ga Forerunner double channel rail, 2" sq. x 12ga. gate ends, and 1" sq. x 14ga. pickets. Gates that exceed 6' in width will have a 1.75" sq. x 14ga. intermediate upright. All rail and upright intersections shall be joined by welding. All picket and rail intersections shall also be joined by welding. Gusset plates will be welded at each upright to rail intersection. Cable kits will be provided for additional trussing for all gates leaves over 6'. Hinges shall be capable of fully supporting the weight of the gate and a load capacity of 1,500 lbs. Hinge-closer device shall be externally mounted with tamper-resistant security fasteners, with full range of adjustability, horizontal (.5" - 1.375") and vertical (0 - .5"). Maintenance free hinge set shall be tested to operate in temperatures of negative 20 F to 200 F degrees, and swings to negative 2 degrees to ensure reliable final lock engagement.

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PART 3 - EXECUTION

3.01 PREPARATION

All new installation shall be laid out by the contractor in accordance with the construction plans. Confirm all existing conditions prior to fabrication of actual fence panels to assure proper clearances for new fencing panels.

3.02 FENCE INSTALLATION

Fence post shall be spaced according to Table 3, plus or minus ½". For installations that must be raked to follow sloping grades, the post spacing dimension must be measured along the grade. Fence panels shall be attached to posts with brackets supplied by the manufacturer. Posts shall be set in concrete footers having a minimum depth of 36" (Note: In some cases, local restrictions of freezing weather conditions may require a greater depth). The "Earthwork" and "Concrete" sections of this specification shall govern material requirements for the concrete footer. Posts setting by other methods such as plated posts or grouted core-drilled footers are permissible only if shown by engineering analysis to be sufficient in strength for the intended application. Said analyses shall be the responsibility of the installation contractor to perform.

3.03 FENCE INSTALLATION MAINTENANCE

When cutting/drilling rails or posts, adhere to the following steps to seal the exposed steel surfaces; 1) Remove all metal shavings from cut area. 2) Apply zinc-rich primer to thoroughly cover cut edge and/or drilled hole; let dry. 3) Apply 2 coats of custom finish paint matching fence color. Failure to seal exposed surfaces per steps 1-3 above will negate warranty. Ameristar spray cans or paint pens shall be used to prime and finish exposed surfaces; it is recommended that paint pens be used to prevent overspray. Use of non-Ameristar parts or components will negate the manufactures' warranty.

3.04 GATE INSTALLATION

Gate posts shall be spaced according to the manufacturers' gate drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected. Type and quantity of gate hinges shall be based on the application; weight, height, and number of gate cycles. The manufacturers' gate drawings shall identify the necessary gate hardware required for the application. Gate hardware shall be provided by the manufacturer of the gate and shall be installed per manufacturer's recommendations.

3.05 CLEANING

The contractor shall clean the jobsite of excess materials; post-hole excavations shall be removed from job area and disposed of in the same manner as other construction debris. Sweep existing surrounding asphaltic and concrete surfaces clean.

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Table 1 – Minimum Sizes for Montage II Posts

<u>Fence Posts</u>		<u>Panel Height</u>		
2-1/2" x 12 Ga.		Up to & Including 6' Height		
3" x 12 Ga.		Over 6' Up to & Including 8' Height		
<u>Gate Leaf</u>	<u>Gate Height</u>			
	<u>Up to & Including 4'</u>	<u>Over 4' Up to & Including 6'</u>	<u>Over 6' Up to & Including 8'</u>	
Up to 4'	2-1/2" x 12 Ga.	3" x 12 Ga.	3" x 12 Ga.	
4'1" to 6'	3" x 12Ga.	4" x 11 Ga.	4" x 11 Ga.	
6'1" to 8'	3" x 12 Ga.	4" x 11 Ga.	6" x 3/16"	
8'1" to 10'	4" x 11 Ga.	6" x 3/16"	6" x 3/16"	
10'1" to 12'	4" x 11 Ga.	6" x 3/16"	6" x 3/16"	
12'1" to 14'	4" x 11 Ga.	6" x 3/16"	6" x 3/16"	
14'1" to 16'	6" x 3/16"	6" x 3/16"	6" x 3/16"	

Table 2 – Coating Performance Requirements

<u>Quality Characteristics</u>	<u>ASTM Test Method</u>	<u>Performance Requirements</u>
Adhesion	D3359 – Method B	Adhesion (Retention of Coating) over 90% of test area (Tape and knife test).
Corrosion Resistance	B117, D714 & D1654	Corrosion Resistance over 1,500 hours (Scribed per D1654; failure mode is accumulation of 1/8" coating loss from scribe or medium #8 blisters).
Impact Resistance	D2794	Impact Resistance over 60 inch lb. (Forward impact using 0.625" ball).
Weathering Resistance	D822 D2244, D523 (60° Method)	Weathering Resistance over 1,000 hours (Failure mode is 60% loss of gloss or color variance of more than 3 delta-E color units).

Table 3 – Montage II – Post Spacing By Bracket Type

Span	For INVINCIBLE® 8' Nominal (91-1/2" Rail)				For CLASSIC, GENESIS, & MAJESTIC 8' Nominal (92-5/8" Rail)					
	2-1/2"	3"	2-1/2"	3"	2-1/2"	3"	2-1/2"	3"	2-1/2"	3"
Bracket Type	Industrial Flat Mount (BB301)*		Industrial Line 2-1/2" (BB319) 3" (BB320)		Industrial Universal 2.5" (BB302) 3" (BB303)		Industrial Flat Mount (BB301)		Industrial Swivel (BB304)*	
Post Settings ± 1/2" O.C.	94-1/2"	95"	94-1/2"	95"	96"	96-1/2"	96"	96-1/2"	*96"	*96-1/2"

*Note: When using BB304 swivel brackets on either or both ends of a panel installation, care must be taken to ensure the spacing between post and adjoining pickets meets applicable codes. This will require trimming one or both ends of the panel. When using the BB301 flat mount bracket for Invincible style, rail may need to be drilled to accommodate rail to bracket attachment.

END OF SECTION

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SECTION 26 0500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General Conditions, Supplemental General Conditions, and Division 01 Specification Sections apply to all Sections of Division 26.

1.2 SUMMARY

- A. This Section includes general administrative and procedural requirements of electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

- 1. Submittals
- 2. Coordination Drawings
- 3. Record Documents
- 4. Maintenance Manuals
- 5. Rough-Ins
- 6. Electrical Installations
- 7. Cutting and Patching

1.3 ELECTRICAL DIVISION INDEX [Edit Index per job requirements]

- A. Section 26 0500 Common Work Results for Electrical
- B. Section 26 0502 Electrical Demolition
- C. Section 26 0519 Low Voltage Electrical Power Conductors and Cables
- D. Section 26 0526 Grounding and Bonding for Electrical Systems
- E. Section 26 0529 Hangers and Supports for Electrical Systems
- F. Section 26 0533 Raceway and Boxes for Electrical Systems
- G. Section 26 0536 Cable Trays for Electrical Systems
- H. Section 26 0543 Underground Ducts and Raceways for Electrical Systems

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- I. Section 26 0548 Seismic Controls for Electrical Systems
- J. Section 26 0550 Installation Coordination
- K. Section 26 0553 Identification for Electrical Systems
- L. Section 26 0573 Electrical System Studies
- M. Section 26 0880 Electrical Acceptance Testing
- N. Section 26 0923 Digital Occupancy and Daylight Management System
- O. Section 26 1213 Liquid Filled, Medium Voltage Transformers
- P. Section 26 2213 Low Voltage Distribution Transformers
- Q. Section 26 2413 Switchboards
- R. Section 26 2416 Panelboards
- S. Section 26 2726 Wiring Devices
- T. Section 26 2813 Fuses
- U. Section 26 2816 Enclosed Switches and Circuit Breakers
- V. Section 26 4313 Transient Voltage Suppression for Low Voltage Electrical Power Circuits
- W. Section 26 5119 LED Interior Lighting
- X. Section 26 5219 Emergency and Exit Lighting
- Y. Section 25 5568 Athletic Field lighting
- Z. Section 26 5612 LED Exterior Lighting

1.4 CODES AND PERMITS

- A. Perform electrical work in strict accordance with the applicable provisions of the National Electrical Code, Latest Edition; National Electric Safety Code, Latest Edition; [the International Building Code, Latest Edition as adopted and interpreted by the State of New Mexico, Pueblo of Zuni, and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. The Contractor shall hold and save the Engineer free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.
- B. Secure and pay for all permits necessary for performance of the work. Pay for all utility connections unless otherwise specified herein.

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- C. The following lists applicable codes and standards that, as a minimum, shall be followed.
1. Applicable county and state electrical codes, laws and ordinances.
 2. National Electrical Manufacturer's Association Standards
 3. National Electrical Code
 4. National Electrical Safety Code
 5. Underwriters Laboratories, Inc. Standards
 6. American National Standards Institute
 7. American Society for Testing Materials Standards
 8. Standards and requirements of local utility companies
 9. National Fire Protection Association Standards
 10. Institute of Electrical and Electronics Engineers Standards
 11. Insulated Cable Engineers Association
 12. Occupational Safety and Health Act
 13. Uniform Fire Code
 14. Americans with Disabilities Act
 15. Commercial and Industrial Insulation Standards (MICA)

1.5 RECORD DRAWINGS

- A. Maintain a complete and accurate set of marked up blue-line prints showing information on the installed location and arrangement of all electrical work, and in particular, where changes were made during construction. Use red color to indicate additions or corrections to prints, green color to indicate deletions, and yellow color to indicate items were installed as shown. Keep record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Architect, Engineer, Owner's Representative, during the construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to record drawing set. Transmit drawings to the Architect, Engineer, Owner's Representative, at the conclusion of the project for delivery to the Owner's Representative.
- B. **PROJECT CLOSEOUT.** In addition to the requirements specified in Division 1, indicate installed conditions for:
1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.

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2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.6 QUALIFICATIONS

- A. All electricians shall be skilled in their respective trade.

1.7 SUBSTITUTIONS

- A. Substitutions:
 1. Substitutions after bid, will only be allowed, for equipment, luminaires, devices, and materials listed within these Specifications and in the Equipment Schedules on the drawings, which will be discontinued with-in six months of construction start.
 2. Substitutions shall be approved in writing by the Owner or the Owners representatives. The determination of the Owner shall be final. All substitution requests shall be submitted for approval two weeks prior to final addendum to actual bid date.
- B. Identification of Division 26 equipment, luminaires, devices, and materials listed within this Specification and in the Equipment Schedules on the drawings, which are identified by manufacturer's name, trade name, and/or model numbers are generally not meant to give preference to any manufacturer, but are provided to establish the design requirements and standards.
- C. Equipment submitted for substitution must fit the space conditions leaving adequate room for maintenance around all equipment. A minimum of 36 inches, or more if required by Code, must be maintained clear in front of all electrical panels, starters, gutters, or other electrical apparatus. Submit drawings showing the layout, size and exact method of interconnection of conduit, wiring and controls specific to each sequence of operation, which shall conform to the manufacturer's recommendations to meet the specifications specific requirements. The scale of these drawings shall be scale of Contract Drawings. The Contractor shall bear the excess costs, by any and all crafts, of fitting the equipment into the space and the system designated. Where additional labor or material is required to permit equipment submitted for substitution to function in an approved manner, this shall be furnished and installed by the Contractor without additional cost to the Owner.
- D. Equipment submitted for substitution shall be approved in writing by the Owner or his representative and shall be accompanied by the following:
 1. A sample of each item submitted for substitution shall accompany the submittal.
 2. Provide a unit price quotation with each item intended for substitution. Include a unit price for the specified item and a unit price for the intended substitute item. Provide a total (per item) of the differential payback to the Owner should the intended substitute item be approved as equivalent to that which is specified.

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3. Reimburse the Owner for the Architect/Engineer's additional services required to review and process substitutions.

1.8 PRIOR APPROVAL

- A. The Engineer will not review submittals for electrical equipment prior to bid ("Prior Approvals"). Refer to specification sections and drawings for requirements and approved vendors.

1.9 HAZARDOUS CONDITIONS

- A. Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

1.10 DEFINITIONS

- A. Definitions of terms will be found in the National Electrical Code.
- B. Whenever a term is used in this Specification which is defined in the Code, the definition given will govern its meaning in this Specification.
- C. Whenever a technical term is used which does not appear in the Code, the definition to govern its meaning in these Specifications will be found in the Standard Dictionary of Electrical and Electronic Terms, published by the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.
- D. "Provide" means furnish, install, connect and test unless otherwise noted.

1.11 SUBMITTALS

- A. The Contractor shall submit submittal brochures of equipment, fixtures and materials to be furnished under Division 26.
- B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review and approval or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.
- C. Install equipment in accordance with the manufacturer's recommendations. Provide accessories and components for optimum operation as recommended by the manufacturer.
- D. Costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.
- E. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification from the Architect/Engineer that submittals have been reviewed and marked either "NO EXCEPTIONS

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TAKEN" or "EXCEPTIONS AS NOTED." Submittals returned marked "EXCEPTIONS AS NOTED" do not require resubmittal provided that the Contractor agrees to comply with all exceptions noted in the submittal, and so states in a letter to the Architect/Engineer.

- F. Review of Submittals: Submittals will be reviewed with reasonable promptness, but only for conformance with the design concept of the Project and for conformance with the information indicated on the Drawings and stated in the Specifications. Review of a separate item as such will not indicate review of the assembly in which the item functions. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions and quantities, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work. Review shall not relieve the Contractor of responsibility for the equipment fitting within the allotted space shown on the drawings with all clearances required for equipment operation, service and maintenance including a minimum of 3 feet clear in front of all electrical equipment and panels as defined by the National Electrical Code. Any relocation of mechanical and/or electrical equipment, materials and systems required to comply with minimum clearances shall be provided by the Contractor without additional cost under the Contract.
- G. Shop Drawings: Unless the following information is included, shop drawings will be returned unchecked:
1. Cover sheet for each submittal, listing equipment, products, and materials, and referencing data and sections in Specifications and drawings. Clearly reference project name and provide space for a review stamp.
 2. Cover sheet shall clearly identify deviations from specifications, and justification.
 3. Include all related equipment in a single submittal to allow complete review. Similar equipment may be submitted under a common cover sheet.
 4. Size, dimensions, and weight of equipment.
 5. Equipment performance under specified conditions, not a copy of scheduled data on drawings.
 6. Indicate actual equipment proposed, where data sheets indicate more than one (1) device or equipment.
- H. Use of substitutions reviewed and checked by the Engineer does not relieve the Contractor from compliance with the Contract Documents. Contractor shall bear all extra expense resulting from the use of any substitutions where substitutions affect adjoining or related work required in this Division or other Divisions of this Specification.
- I. If Contractor substitutes equipment for that drawn to scale on the drawings, he shall prepare a 1/4" = 1'-0" installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will fit space with adequate clearances for maintenance. This 1/4" = 1'-0" fabrication drawing shall be submitted, for review by the Architect, Engineer, Owner's Representative, with the shop drawing submittals of the substituted. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

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- J. Submittals and one (1) resubmittal will be reviewed by the Architect/Engineer. If the Contractor fails to provide the required data with his second submittal, he will be charged for the third and subsequent reviews at \$200 dollar per hour.
- K. The Contractor shall submit a maximum amount of one PDF copy of submittal brochures for review. Brochures shall be submitted within thirty (30) days after contract award. A copy of all submittals will be retained by the Engineer, and PDF response sets returned to the Architect.

1.12 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 - PROJECT CLOSEOUT. In addition to the requirements specified in Division 1, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.

1.13 COORDINATION DRAWINGS

- A. Prepare coordination drawings in accordance with Division 1, Section "PROJECT COORDINATION", to a scale of 1/8" = 1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
 - 1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
 - a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 - b. Exterior wall and foundation penetrations.
 - c. Fire-rated wall and floor penetrations.
 - d. Equipment connections and support details.
 - e. Sizes and location of required concrete pads and bases.
 - 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

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3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communications systems components, sprinklers, and other ceiling-mounted devices.

1.14 USE OF CADD FILES

- A. Under certain conditions, the Contractor will be permitted the use of the Engineer's CADD files for documentation of as-builts, submittals, or coordination drawings.
- B. The Engineer shall be compensated for the time required to format the CADD files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc.
- C. The Contractor shall complete the enclosed License, Indemnity and Warranty Agreement, complete with contractor's name, address, and Contractor's Representative signature prior to request for CADD file usage.

1.15 DRAWINGS AND SPECIFICATIONS

- A. Electrical drawings are diagrammatic, but shall be followed as closely as actual construction and work of the other sections shall permit. Size and location of equipment is drawn to scale wherever possible. Do not scale from electrical drawings.
- B. Drawings and specifications are for the assistance and guidance of the Contractor. Exact locations, distances, and levels will be governed by the building. The Contractor shall make use of data in all the Contract Documents to verify information at the building site.
- C. In any case where there appears to be a conflict between that which is shown on the electrical drawings, and that shown in any other part of the Contract Documents, the Contractor shall notify and secure directions from the Architect.
- D. Drawings and specifications are intended to complement each other. Where a conflict exists between the requirements of the drawings and/or the specifications, request clarification. Do not proceed with work without direction.
- E. The Architect shall interpret the drawings and the specifications. The Architect's interpretation as to the true intent and meaning thereof and the quality, quantity, and sufficiency of the materials and workmanship furnished there under shall be accepted as final and conclusive.
- F. In the case of conflicts not clarified prior to the bidding deadline, use the most costly alternative (better quality, greater quantity, and larger size) in preparing the bid. A clarification will be issued to the successful bidder as soon as feasible after the award and, if appropriate, a deductive change order will be issued.
- G. Where items are specified in the singular, this division shall provide the quantity as shown on drawings plus any spares or extras indicated on the drawings or in the specifications.

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- H. Investigate structural and finish conditions and arrange work accordingly. Provide all fittings, equipment, and accessories required for actual conditions.

1.16 SIMILAR MATERIALS

- A. All items of a similar type shall be products of the same manufacturer.
- B. Contractor shall coordinate among suppliers of various equipment to assure that similar equipment type is product of the same manufacturer.
- C. Examples of similar equipment types include but are not limited to:
 - 1. Power Circuit Breakers
 - 2. Enclosed Case Circuit Breakers
 - 3. TVSS
 - 4. Motor Starters
 - 5. Transformers
 - 6. Panelboards
 - 7. Disconnects
 - 8. Fuses

1.17 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.18 GUARANTEE-WARRANTY

- A. The following guarantee is a part of the specifications and shall be binding on the Contractor:

"The Contractor guarantees that this installation is free from ALL defects. He agrees to replace or repair any part of the installation which may fail within a period of one (1) year after date established below, provided that such failure is due to defects in the materials or workmanship or to failure to follow the specifications and drawings. Warranty of the Contractor-furnished equipment or systems shall begin on the date the system or equipment is placed in operation for beneficial use of the Owner or occupancy by the Owner, whichever occurs first; such date to be determined in writing by means of issuing a 'Certificate of Substantial Completion', AIA Form G704."
- B. The extent of guarantees or warranties by Equipment and/or Materials Manufacturers shall not diminish the requirements of the Contractor's guarantee-warranty to the Owner.

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- C. All items of electrical equipment furnished and installed under Division 26 shall be provided with a full two (2) year parts and labor warranty.

PART 2 - PRODUCTS

2.1 QUALITY OF MATERIALS

- A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of electrical equipment, and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.
- B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.2 ALTITUDE RATINGS

- A. Unless otherwise noted, all specified equipment capacities are for an altitude of 6,293 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

2.3 EQUIPMENT REQUIREMENTS

- A. The electrical requirements for equipment specified or indicated on the drawings are based on information available at the time of design. If equipment furnished for installation has electrical requirements other than those indicated on the electrical drawings, make all adjustments to wire and conduit size, controls, over current protection and installation as required to accommodate the equipment supplied. Delineate all adjustments to the drawings reflecting the electrical system in a submittal to the Contract Administrator immediately upon knowledge of the required adjustment.
- B. Approved Equipment and Conductors: ALL equipment and conductors shall be listed and labeled by a nationally recognized testing laboratory (NRTL). The NRTL shall be listed by the federal occupational safety and health administration. Conformance with the State of New Mexico Electrical Code article 110.2 is required for ALL equipment and conductors.

PART 3 - EXECUTION

3.1 COOPERATION WITH OTHER TRADES

- A. Coordinate all work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings.

3.2 DRAWINGS

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- A. The electrical drawings show the general arrangement of all lighting, power, special systems, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents shall be considered as part of the work. Coordinate with architectural, mechanical, and structural drawings. Because of the small scale of the electrical drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Provide all fittings, boxes, and accessories as may be required to meet actual conditions. Should conditions necessitate a rearrangement of equipment, such departures and the reasons therefore, shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No changes shall be made without the prior written approval. All changes shall be marked on record drawings.
- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.
- C. Installation of all equipment shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearance, as defined by the National Electrical Code (NEC).
- D. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 26 with the associated architectural, structural, and mechanical work than is normally necessary for a more typical facility.
- E. The installation of all concealed electrical systems shall be carefully arranged to fit within the available space without interference with adjacent structural and mechanical systems.

3.3 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical system, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical systems, equipment, and materials installation with all other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in all other building components during progress of construction, to allow for electrical installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum clearance possible.

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7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Branch circuits in all areas to have an individual neutral for each phase.
9. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
10. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
11. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
12. Install access panel or doors where units are concealed behind finished surfaces.
13. Install systems, materials, and equipment giving right-of-way priority to systems requiring installation at a specified slope.

3.4 FIELD MEASUREMENTS

- A. No extra compensation shall be claimed or allowed due to differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, and shall report any work which must be corrected. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the electrical work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor.

3.5 EQUIPMENT SUPPORT

- A. Provide support for equipment to the building structure. Provide all necessary structures, inserts, sleeves, firestops and hanging devices for installation of equipment. Coordinate installation of devices. Verify with the Architect that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.6 PAINTING

- A. All finish painting of electrical systems and equipment will be under "Painting," unless equipment is hereinafter specified to be painted.
- B. All equipment shall be provided with factory applied standard finish, unless otherwise specified.

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- C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished to the satisfaction of the Architect, Engineer, and Owner's Representative.

3.7 SEISMIC SUPPORTS

- A. The Contractor shall be responsible for all anchors and connections for the electrical work to the building structure to prevent damage of equipment and systems due to seismic activity.
- B. See Section 26 0548 Seismic Controls for Electrical Systems for requirements for seismic supporting of electrical equipment and systems.

3.8 PROTECTION OF MATERIALS AND EQUIPMENT

- A. The Contractor shall be responsible for the protection of all work, materials and equipment furnished and installed under this section of the specifications, whether incorporated in the building or not.
- B. All items of electrical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner approved by the Architect, Engineer, and Owner's Representative.
- C. The Contractor shall provide protection for all work and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Architect, Engineer, and Owner's Representative prior to such storage.
- D. Conduit openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the work, fixtures, equipment and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Architect, Engineer, and Owner's Representative.

3.9 EXCAVATION

- A. Provide all excavation, trenching and backfilling required.
- B. Slope sides of excavations to comply with codes and ordinances. Shore and brace as required for stability of excavation.

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS "Structural Welding Code."

3.11 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

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- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Select fastener sizes that will not 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 members.
- C. Attach to substrates as required to support applied loads.

3.12 APPLICATION OF JOINT SEALERS

- A. General: Comply with joint sealer manufacturer's printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
 - 1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
 - 2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.
- B. Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.
- C. Firestopping Sealant: Provide sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.13 INSTALLATION OF ACCESS DOORS

- A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
- B. Adjust hardware and panels after installation for proper operation.

3.14 CUTTING AND PATCHING

- A. Perform cutting and patching in accordance with Division 1, Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:
 - 1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Remove and replace defective Work.
 - b. Remove and replace Work not conforming to requirements of the Contract Documents.
 - c. Remove samples of installed Work as specified for testing.

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- d. Install equipment and materials in existing structures.
 - e. Upon written instructions from the Contracting Officer, uncover and restore Work to provide for Contracting Officer observation of concealed Work.
2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
 3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
 5. During cutting and patching operations, protect adjacent installations.
 6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced installers.

3.15 MANUFACTURER'S INSTRUCTIONS

- A. All equipment shall be installed in strict accordance with recommendations of the manufacturer. If such recommendations conflict with plans and specifications, the Contractor shall submit such conflicts to the Architect, Engineer, and Owner's Representative who shall make such compromises as he deems necessary and desirable.

3.16 OWNER FURNISHED EQUIPMENT

- A. Included in Work Scope:
 1. Follow and expedite the delivery of each piece of equipment to assure the equipment delivery stays on schedule. Notify the Owner of any problems or delays.
 2. Receive, unload, uncrate, and install each item of pre-purchased and Owner furnished equipment.
 3. Confirm that each item has been received complete and as specified. Notify the Owner and the manufacturer's representative in writing of any deficiencies or damage.
 4. Coordinate with the manufacturer's representative on start-up and provide factory personnel, and provide all necessary personnel to assist Owner's operating personnel and/or manufacturer's service personnel in start-up and commissioning.
 5. Provide all items not listed as pre-purchased.
- B. The Contractor shall not be responsible for the following in regards to pre-purchased and Owner furnished equipment:
 1. Payment

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2. Equipment Warranty
 3. Submittals
 4. Operating and Maintenance Manuals
 5. Equipment Performance
- C. Submittals, installation instructions, and warranty provisions for pre-purchased equipment will be furnished to the Contractor by the Owner.

3.17 CONCRETE BASES AND HOUSEKEEPING PADS

- A. Install concrete bases and housekeeping pads under all freestanding electrical equipment unless otherwise noted.
- B. Contractor shall be responsible for the accurate dimensions of all pads and bases and shall furnish and install all anchor bolts, etc. Coordinate weight of concrete bases and housekeeping pads with the structural engineer.
- C. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these specifications. Pad foundations shall be 4" high minimum, unless otherwise indicated on the drawings. Chamfer edges shall be 1". Faces shall be free of voids and rubbed smooth with Carborundum block after stripping forms. Tops shall be level. Provide dowel rods or other required material in floor for lateral stability and anchorage.
- D. Equipment anchor bolts shall be set in a galvanized pipe or sheet metal sleeves 1" larger than bolt diameter. Anchor bolts shall be high strength steel J shape. Anchor bolt design shall be arranged and paid for by the Contractor.

3.18 TESTS

- A. All tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect, Engineer, and Owner's Representative one week in advance of all tests. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

3.19 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. The Contractor shall furnish the complete operating and maintenance instructions covering all units of electrical equipment herein specified together with parts lists. Furnish two (2) copies of all the literature; each shall be suitably bound in loose leaf book form.
- B. Operating and maintenance manuals as required herein shall be submitted for review not less than two (2) weeks prior to the date scheduled for the Contractor to provide Operating and Maintenance Instructions to the Owner as specified herein.

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- C. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the electrical systems and equipment for a period of five (5) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his representative in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks' notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.
- D. The Contractor shall video tape the instruction and training sessions using a VHS or DVD camcorder, and at the completion and acceptance (by Owner and Architect) of the training sessions, the Contractor shall submit (2) copies of the video tape.

3.20 CERTIFICATIONS

- A. Before receiving final payment, certify in writing that all equipment furnished and all work done is in compliance with all applicable codes mentioned in these specifications. Submit certifications and acceptance certificates to the Architect, Engineer, and Owner's Representative including proof of delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

3.21 INTERRUPTING SERVICES

- A. The Contractor shall coordinate the installation of all work within the building in order to minimize interference with the operation of existing building electrical telephone, fire alarm, and utility systems during construction. Connections to existing systems requiring the interruption of service within the building shall be carefully coordinated with the Owner to minimize system downtimes. Requests for the interruption of existing services shall be submitted in writing a minimum of two (2) weeks before the scheduled date. Absolutely no interruption of the existing services will be permitted without the written review.

3.22 OPERATION PRIOR TO ACCEPTANCE

- A. Operation of equipment and systems installed by the Contractor for the benefit of the Owner prior to substantial completion will be allowed providing a written agreement between the Owner and the Contractor has established warranty and other responsibilities to the satisfaction of both parties.

3.23 SITE VISITS AND OBSERVATION OF CONSTRUCTION

- A. The Architect/Engineer will make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation by the Architect/Engineer however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities, nor shall the Architect/Engineer have authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided

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by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

END OF SECTION

DIVISION 26 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.

PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____

Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES NO
If YES, explain: _____

2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES NO

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES NO

5. What affect does substitution have on other trades? _____

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES NO
If YES, explain: _____

7. Will substitution affect progress schedule? YES NO
If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES NO
If YES, explain: _____

9. Is substitution identical in appearance and function to specialized product? YES NO

Submitting Firm: _____	Date: _____
Address: _____	
Signature: _____	Telephone: _____

For Engineer's Use Only		
Accepted: _____	Not Accepted: _____	Received Too Late: _____
By: _____	Date: _____	
Remarks: _____		

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for back-up and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

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SECTION 26 0502 – DEMOLITION 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.
- B. See Section 260500 for Common Work Results for Electrical.

1.2 SCOPE OF WORK

- A. Provide all material, equipment and labor as required to remove, relocate and/or reconnect all electrical work identified in these specifications and indicated on the drawings.

1.3 SUMMARY

- A. This Section includes limited scope, general construction materials and methods for application with electrical installations as follows:
 - 1. Selective demolition including:
 - a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
 - b. Dismantling electrical materials and equipment made obsolete by these installations.
 - 2. Excavation for underground utilities and services, including underground raceways.
 - 3. Miscellaneous metals for support of electrical materials and equipment.
 - 4. Nailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
 - 5. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - 6. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.4 PROJECT CONDITIONS

- A. Conditions affecting selective demolition: The following project conditions apply:

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1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
 2. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
- B. Conditions affecting excavations: The following project conditions apply:
1. Maintain and protect existing building services which transit the area affected by selective demolition.
 2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
 3. Existing utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
 4. Remove existing underground utilities indicated to be removed.
 - a. Uncharted or incorrectly charted utilities: Contact utility owner immediately for instructions.
 - b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Owner's Representative prior to utility interruption.
 5. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Verify field measurements and circuiting arrangements as shown on drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents. Report discrepancies to Architect/Engineer before disturbing existing installation.
- D. Beginning of demolition means Contractor accepts existing conditions.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Disconnect and remove electrical systems in walls, floors, and ceilings scheduled for removal.

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- B. Coordinate utility service outages with Owner a minimum of 72 hours prior to outage.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical and Fire Alarm system: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switch overs and connections. Obtain permission from the Owner's Representative at least 72 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.2 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Demolish and extend existing electrical work under provisions of this section.
- B. Remove, relocate and extend existing installations to accommodate new construction. Re-circuit and reconnect all electrical lighting, outlets, and equipment not scheduled for removal that have become disconnected due to demolition work.
- C. Remove abandoned wiring to source of supply.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit serving them is removed. Provide blank cover for abandoned outlets which are not removed. Provide blank cover for abandoned outlets which are not removed.
- F. Disconnect and remove abandoned panelboards and distribution equipment.
- G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- H. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers, and other accessories.
- I. Repair adjacent construction and finishes damaged during demolition and extension work. Any damage to building, piping or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner.
- J. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.
- K. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.
- L. Removal and replacement of ceiling tile(s) to perform work operations shall be the responsibility of the Contractor. The Contractor shall be responsible for replacement of any ceiling tiles or framework that may become damaged at no cost to the Owner

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- M. Disconnect and remove [].
- N. Housekeeping Pads and Equipment Foundations: Remove for all equipment removal. Backfill as required, compact to 95 percent modified Proctor density, and pour floor slab or resurface floor to match existing.
- O. Conduit in Concealed Locations: Remove conductors, cap both ends of conduit, and label conduit as "Abandoned" at both ends. Where conduit runs below grade, cap both ends of conduit and abandon in place. Where conduit runs below floor slab, additionally, chip out concrete around conduit, remove conduit to bottom of slab level, and patch floor to match existing.
- P. Motor Control Centers: Where MCCs serve equipment to be removed and no new equipment is to be served, leave starter in place, remove existing labels, and install new label "Spare Size x Starter."

3.3 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused.
- B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
- C. Luminaries: Remove existing luminaries for cleaning, as indicated on drawings. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.
- D. Materials and equipment to be salvaged: Remove, demount, and disconnect existing electrical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.
- E. Disposal and cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

3.4 INSTALLATION

- A. Install relocated materials and equipment under the provisions of this section.

3.5 ITEMS SALVAGED TO OWNER

- A. All items removed and or salvaged will have Owner first right of refusal and approval for removal from site. Move and store in dry location as directed. Refuse materials and items not salvaged shall be removed from the site and legally disposed of.

END OF SECTION

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SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. Copper building wire.
2. Aluminum building wire.
3. Nonmetallic underground conduit with conductors, Type NUCC.
4. Metal-clad cable, Type MC.
5. Armored cable, Type AC.
6. Photovoltaic cable, Type PV.
7. Mineral-insulated cable, Type MI.
8. Tray cable, Type TC.
9. Fire-alarm wire and cable.
10. Connectors and splices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35 000 V.

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4. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
5. Section 271313 "Communications Copper Backbone Cabling" for twisted pair cabling used for data circuits.
6. Section 271513 "Communications Copper Horizontal Cabling" for twisted pair cabling used for data circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

1.4 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Alpha Wire Company.
 2. American Bare Conductor.
 3. Belden Inc.
 4. Cerro Wire LLC.
 5. Encore Wire Corporation.
 6. General Cable Technologies Corporation.
 7. Okonite Company (The).
 8. Service Wire Co.
 9. Southwire Company.
 10. WESCO.

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C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B496 for stranded conductors.

E. Conductor Insulation:

1. Type NM: Comply with UL 83 and UL 719.
2. Type RHH and Type RHW-2: Comply with UL 44.
3. Type USE-2 and Type SE: Comply with UL 854.
4. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
5. Type THHN and Type THWN-2: Comply with UL 83.
6. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
7. Type UF: Comply with UL 83 and UL 493.
8. Type XHHW-2: Comply with UL 44.
9. <Insert Type and standard>.

F. Shield:

1. Type TC-ER: Cable designed for use with ASDs, with oversized crosslinked polyethylene insulation, [spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire] [dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires], and sunlight- and oil-resistant outer PVC jacket.

2.2 FIRE-ALARM WIRE AND CABLE

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

1. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Genesis Cable Products; Honeywell International, Inc.

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5. Radix Wire.
 6. Rockbestos-Suprenant Cable Corp.
 7. Superior Essex Inc.
 8. West Penn Wire.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG size as recommended by system manufacturer.
1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.3 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
 2. ABB (Electrification Products Division).
 3. Appleton - O-Z/Gedney; Emerson Electric Co., Automation Solutions.
 4. Atkore International (AFC Cable Systems).
 5. Gardner Bender.
 6. Hubbell Incorporated, Power Systems.

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7. Ideal Industries, Inc.
 8. ILSCO.
 9. NSi Industries LLC.
 10. Service Wire Co.
 11. TE Connectivity Ltd.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper.
 2. Type: Two hole with standard long barrels.
 3. Termination: Compression.

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 must be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
1. Minimum #12 conductors to be used throughout building unless noted in the specifications or in the plans.
 2. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 3. Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.
- C. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.
- D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 INSTALLATION, GENERAL

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

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- B. 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.
- C. 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.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.3 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

- A. Comply with NFPA 72.
- B. Wiring Method: Install wiring in metal pathway according to Section 270528.29 "Hangers and Supports for Communications Systems."
 - 1. Install plenum cable in environmental airspaces, including plenum ceilings.
 - 2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
 - a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
 - 3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is not permitted.
 - 4. Signaling Line Circuits: Power-limited fire-alarm cables must not be installed in the same cable or pathway as signaling line circuits.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

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- E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.
- F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.
- G. Wiring to Remote Alarm Transmitting Device: 1 inch conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

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 12 inch of slack.
- D. Comply with requirements in Section 283100 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

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."

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3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to **Section 078413** "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Tests and Inspections:
1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 2. After installing conductors and cables and before electrical circuitry has been energized, test **service entrance and feeder conductors, and conductors** feeding the following critical equipment and services for compliance with requirements:
 - a. Switchboard,
 - b. Panelboards.
 - c. Transformers,
 - d. Mechanical system Equipment
 - e. Plumbing system Equipment.
 - f. Appliances and vending machines
 - g. Special equipment such as copiers and the like.
 3. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
 - g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
 4. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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- b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- 5. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.
- C. Related Requirements:
 - 1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
 - 2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
- B. Field quality-control reports.

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1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 260500 "Common Work Results for Electrical systems" include the following:
 - a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - 1) Test wells.
 - 2) Ground rods.
 - 3) Ground rings.
 - 4) Grounding arrangements and connections for separately derived systems.
 - b. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems, based on NETA MTS and NFPA 70B.
 - 1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

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 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - 1. ABB, Electrification Products Division.
 - 2. Advanced Lightning Technology, Ltd.
 - 3. Burndy; Hubbell Incorporated, Construction and Energy.
 - 4. Dossert; AFL Telecommunications LLC.
 - 5. ERICO; nVent.
 - 6. Fushi Copperweld Inc.
 - 7. Galvan Industries, Inc.; Electrical Products Division, LLC.

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8. Harger Lightning & Grounding.
9. ILSCO.
10. O-Z/Gedney; Emerson Electric Co., Automation Solutions, Appleton Group.
11. Robbins Lightning, Inc.
12. Siemens Industry, Inc., Energy Management Division.

2.3 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 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 inch wide and 1/16 inch thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4" by 4 inch by 12" in cross section, with 9/32 inch holes spaced 1-1/8 inch apart. Stand-off insulators for mounting must comply with UL 891 for use in switchboards, 600 V and must be Lexan or PVC, impulse tested at 5000 V.

2.4 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. Mechanical-Type Bus-Bar Connectors: Cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

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- D. Compression-Type Bus-Bar Connectors: Copper or copper alloy, with two wire terminals.
- E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- H. Conduit Hubs: Mechanical type, terminal with threaded hub.
- I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- N. Straps: Solid copper, copper lugs. Rated for 600 A.
- O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.
- P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- Q. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with stainless steel bolts.
 - a. Material: Die-cast zinc alloy.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad; 3/4 inch by 10 ft.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inch long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.
- C. Ground Plates: 1/4 inch thick, hot-dip galvanized.

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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. Underground Grounding Conductors: Install bare copper conductor, **No. 4/0 AWG** minimum.
 - 1. Bury at least 30 inch below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
- C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.
- D. Isolated Grounding Conductors: Green-colored insulation with more than one continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- E. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 6 inch 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.
- F. 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 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors must be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

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3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode must be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch above to 6 inch below concrete. Seal floor opening with waterproof, non-shrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inch from the foundation.

3.5 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.

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- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- F. Metallic Fences: Comply with requirements of IEEE C2.
 - 1. Grounding Conductor: Bare, copper, not less than **No. 8 AWG**.
 - 2. Gates: Must be bonded to the grounding conductor with a flexible bonding jumper.
 - 3. Barbed Wire: Strands must be bonded to the grounding conductor.

3.6 FENCE GROUNDING

- A. Fence Grounding: Install at maximum intervals of 500 ft. except as follows:
 - 1. Fences within 100 ft. of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of **500 ft.**
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.
 - 2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inch below finished grade.
- B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 ft. on each side of crossing.
- C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
- D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inch below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
- E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

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3.7 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 Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are **2 inch** 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.
 - 2. Use exothermic welds for all below-grade connections.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch deep, with cover.
 - 1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. 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.
- F. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of

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the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install copper bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft. apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item on plans.
1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inch from building's foundation.
- J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 ft. of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 ft. long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
- K. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.

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5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.8 FIELD QUALITY CONTROL

A. 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, at ground test wells, 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.

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

C. Prepare test and inspection reports.

D. 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. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

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END OF SECTION

SECTION 26 0529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Support, anchorage, and attachment components.
 2. Fabricated metal equipment support assemblies.

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 the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Sockets.
 - e. Eye nuts.
 - f. Fasteners.
 - g. Anchors.
 - h. Saddles.
 - i. Brackets.
 2. Include rated capacities and furnished specialties and accessories.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. 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.
- C. Delegated Design Submittal: For hangers and supports for electrical systems.
1. Include design calculations and details of hangers.

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2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

- A. 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

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.
- B. 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 diameter holes at a maximum of 8 inch on center in at least one surface.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. B-line; Eaton, Electrical Sector.
 - d. CADDY; nVent.
 - e. Flex-Strut Inc.
 - f. Gripple Inc.
 - g. G-Strut.
 - h. Haydon Corporation.
 - i. Metal Ties Innovation.
 - j. MIRO Industries.
 - k. Unistrut; Atkore International.
 - l. Wesanco, Inc.

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2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Material for Channel, Fittings, and Accessories: [Galvanized steel] [Plain steel] [Stainless steel, Type 304] [Stainless steel, Type 316].
 4. Channel Width: Selected for applicable load criteria 1-5/8 inch.
 5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel and malleable-iron 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 must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must 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.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) B-line; Eaton, Electrical Sector.
 - 2) Empire Tool and Manufacturing Co., Inc.

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- 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
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.
 6. Toggle Bolts: All 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 SELECTION

- A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA NEIS 101
 2. NECA NEIS 102.
 3. NECA NEIS 105.
 4. NECA NEIS 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 "Raceway and Boxes for Electrical Systems."
- D. Provide vibration and seismic controls with hangers and supports in accordance with requirements specified in "Section 260548 "Seismic Controls for Electrical Systems."

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- E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as scheduled in NECA NEIS 1, where its Table 1 lists maximum spacing's that are less than those stated in NFPA 70. Minimum rod size must be 1/4 inch in diameter.
- F. 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 [two-bolt conduit clamps] [single-bolt conduit clamps] [single-bolt conduit clamps using spring friction action for retention in support channel].
- G. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION

A. MANUFACTURED SUPPORTING DEVICES

- 1. Conduit Sealing Bushing: Factory-fabricated watertight conduit sealing busing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps and cap screws.
- 2. U-Channel Systems: 16-gauge steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacturer.

B. FABRICATED SUPPORTING DEVICES

- 1. Pipe Sleeves: Provide pipe sleeves of one of the following:
- 2. Sheetmetal: Fabricate from galvanized sheetmetal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gauge metal for sleeve diameter noted:
 - a. 3-inch and smaller: 20-gauge.
 - b. 4-inch to 6-inch: 16-gauge.
 - c. Over 6-inch: 14-gauge.
- 3. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
- 4. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

C. Raceway Supports: Comply with the NEC and the following requirements:

- 1. Conform to manufacturer's recommendations for selection and installation of supports.

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2. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring and steel fasteners that are specifically designed for supporting single conduits or tubing.
 3. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
 4. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
 5. In vertical runs, arrange support so the load produced by the weight of the raceways and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
- D. Vertical Conductor Supports: Install simultaneously with installation of conductors.
- E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheetmetal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.
- G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire-rated-wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.
- H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:
1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe

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straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheetmetal screws.

2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
 3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.
- J. Tests: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:
1. Expansion anchors.
 2. Toggle bolts.
 3. Powder-driven threaded studs.
- K. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the Contracting Officer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

TABLE I: SPACING FOR RACEWAY SUPPORTS

Raceway Size, In.	Location	RMC & IMC (1)	EMT (1)
1/2-1	Any Location	7	7
1 & Larger	Any Location	10	10

NOTES:

1. Maximum spacing of supports (feet).
2. Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

Abbreviations:

EMT Electrical metallic tubing.
IMC Intermediate metallic conduit.
RMC Rigid metallic conduit.

3.3 INSTALLATION OF SUPPORTS

- A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

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- B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT, IMC, and RMC may be supported by openings through structure members, in accordance with 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 must be weight of supported components plus 200 lb.
- 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 Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69 Spring-tension clamps.
 - 7. To Light Steel: Sheet metal screws.
 - 8. 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.

3.4 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 D1.2/D1.2M. Submit welding certificates.

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3.5 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use **3000 psi**, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.6 PAINTING

- A. Touchup:
 - 1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
 - 2. Comply with requirements in Section 099113 "Exterior Painting", Section 099123 "Interior Painting", and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

SECTION 26 0533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

- A. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

1.2 SUMMARY

- A. Section Includes:
 - 1. Type EMT-S raceways and elbows.
 - 2. Type ENT raceways and fittings.
 - 3. Type EPEC raceways and fittings.
 - 4. Type ERMC-S raceways, elbows, couplings, and nipples.
 - 5. Type FMC-S.
 - 6. Type FMT raceways.
 - 7. Type IMC raceways.
 - 8. Type LFMC raceways.
 - 9. Type PVC raceways and fittings.
 - 10. Type RTRC-AG raceways and fittings.
 - 11. Fittings for conduit, tubing, and cable.
 - 12. Threaded metal joint compound.
 - 13. Solvent cements.
 - 14. Surface metal raceways and fittings.
 - 15. Strut-type channel raceways and fittings.
 - 16. Wireways and auxiliary gutters.
 - 17. Metallic outlet boxes, device boxes, rings, and covers.
 - 18. Nonmetallic outlet boxes, device boxes, rings, and covers.

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19. Termination boxes.
20. Cabinets, cutout boxes, junction boxes, pull boxes, and miscellaneous enclosures.
21. Cover plates for device boxes.
22. Hoods for outlet boxes.

B. Related Requirements:

1. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.
3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
4. Section 270543 "Underground Pathways and Structures for Communication Systems" for exterior communications duct banks, manholes, and underground utility construction.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Wireways and auxiliary gutters.
2. Surface metal raceways.
3. Surface nonmetallic raceways.
4. Floor boxes.
5. Cabinets, cutout boxes, and miscellaneous enclosures.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details. Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness at location where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

C. Samples: For wireways, surface raceways, and floor boxes for colors and textures specified, 12 inch long.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions:

1. For Type ERM-C-S-PVC.

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PART 2 - PRODUCTS

2.1 TYPE EMT-SS RACEWAYS AND ELBOWS

- A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL 797A and UL Category Control Number FJMX.
- B. Stainless Steel Electrical Metal Tubing (EMT-SS) and Elbows:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Calconduit; Atkore International.
 2. Material: Stainless steel.
 3. Options:
 - a. Minimum Trade Size: trade size 3/4.
 - b. Colors: As indicated on Drawings.

2.2 TYPE EMT-S RACEWAYS AND ELBOWS

- A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL 797 and UL Category Control Number FJMX.
- B. Steel Electrical Metal Tubing (EMT-S) and Elbows:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Calconduit; Atkore International.
 - c. Emerson Electric Co.
 - d. Picoma; Zekelman Industries.
 - e. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - f. Topaz Lighting & Electric.
 - g. Western Tube; Zekelman Industries.
 - h. Wheatland Tube; Zekelman Industries.
 2. Material: Steel.
 3. Options:
 - a. Exterior Coating: Zinc.

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- b. Interior Coating: Zinc.
- c. Minimum Trade Size: trade size 3/4).
- d. Colors: As indicated on Drawings.

2.3 TYPE ENT RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 1653 and UL Category Control Number FKHU.

B. Electrical Nonmetallic Tubing (ENT) and Fittings:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Cantex Inc.
 - c. JM Eagle; J-M Manufacturing Co., Inc.
- 2. Options:
 - a. Minimum Trade Size: trade size 3/4.
 - b. Fittings:
 - 1) Mechanically Attached Fittings: UL 1653.
 - 2) Solvent-Attached Fittings: UL 651.

2.4 TYPE EPEC RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 651A and UL Category Control Number EAZX.

B. Schedule 40 Electrical HDPE Underground Conduit (EPEC-40):

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Blue Diamond Industries.
 - b. JM Eagle; J-M Manufacturing Co., Inc.
 - c. Petroflex North America.
 - d. Prysmian Cables and Systems; Prysmian Group North America.
 - e. Southwire Company.
- 2. Dimensional Specifications: Schedule 40.
- 3. Options:

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- a. Minimum Trade Size: trade size 3/4.
- C. Schedule 80 Electrical HDPE Underground Conduit (EPEC-80):
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Blue Diamond Industries.
 - b. JM Eagle; J-M Manufacturing Co., Inc.
 - c. Petroflex North America.
 - d. Prysmian Cables and Systems; Prysmian Group North America.
 - e. Southwire Company.
 - 2. Dimensional Specifications: Schedule 80.
 - 3. Options:
 - a. Minimum Trade Size: trade size 3/4.

2.5 TYPE ERMC-SS RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

- A. Performance Criteria:
- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: UL 6A and UL Category Control Number DYWV.
 - 3. Options:
 - a. Protective Coating: Provide protective coating for direct burial.
 - b. Minimum Trade Size: trade size 3/4).
 - c. Colors: As indicated on Drawings.
- B. Stainless Steel Electrical Rigid Metal Conduit (ERMC-SS), Elbows, Couplings, and Nipples:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Calconduit; Atkore International.
 - d. Crouse-Hinds; Eaton, Electrical Sector.
 - e. Patriot Aluminum Products, LLC.
 - 2. Material: Stainless steel.
 - 3. Options:
 - a. Minimum Trade Size: trade size 3/4.
 - b. Colors: As indicated on Drawings.

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2.6 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

- A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL 6 and UL Category Control Number DYIX.
- B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Calconduit; Atkore International.
 - c. Crouse-Hinds; Eaton, Electrical Sector.
 - d. Killark; Hubbell Incorporated, Construction and Energy.
 - e. Patriot Aluminum Products, LLC.
 - f. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - g. Topaz Lighting & Electric.
 - h. Western Tube; Zekelman Industries.
 - i. Wheatland Tube; Zekelman Industries.
 2. Exterior Coating: Zinc.
 3. Options:
 - a. Interior Coating: Zinc.
 - b. Minimum Trade Size: trade size 3/4).
 - c. Colors: As indicated on Drawings.
- C. PVC-Coated-Steel Electrical Rigid Metal Conduit (ERMC-S-PVC), Elbows, Couplings, and Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Bluesteel Services LLC.
 - c. Calbond; Atkore International.
 - d. KorKap; Robroy Industries.
 - e. Perma-Cote; Robroy Industries.
 - f. Plasti-Bond; Robroy Industries.
 2. Additional Characteristics:
 - a. Fittings for PVC-Coated Conduit:
 - 1) Minimum coating thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
 - 2) Conduit bodies must be Form 8 with an effective seal and a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury

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(vacuum) for 72 hours must be available. Conduit bodies must be supplied with plastic-encapsulated stainless steel cover screws.

- 3) Form 2 inch long or one pipe diameter long, whichever is less, PVC sleeve at openings of female fittings, except unions. Inside sleeve diameter must be matched to outside diameter of metal conduit.
 - 4) PVC coating on the outside of conduit couplings must be protected from tool damage during installation.
 - 5) Female threads on fittings and couplings must be protected by urethane coating.
 - 6) Fittings must be from same manufacturer as conduit.
 - 7) Beam clamps and U bolts must be formed and sized to fit outside diameter of coated conduit. Plastic-encapsulated nuts must cover the exposed portions of threads.
3. Options:
- a. Exterior Coating: PVC complying with NEMA RN 1 and marked ETL Verified PVC-001.
 - b. Interior Coating: Zinc.
 - c. Minimum Trade Size: trade size 3/4.
 - d. Colors: As indicated on Drawings.
 - e. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - f. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.7 TYPE FMC-S RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1 and UL Category Control Number DXUZ.

B. Steel Flexible Metal Conduit (FMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Electri-Flex Company.
 - c. Topaz Lighting & Electric.
2. Material: Steel.
3. Options:
 - a. Minimum Trade Size: [Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)].
 - b. Colors: As indicated on Drawings.
4. Options:
 - a. Minimum Trade Size: trade size 3/4.

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- b. Colors: As indicated on Drawings.

2.8 TYPE FMT RACEWAYS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 1652 and UL Category Control Number ILJW.

B. Steel Flexible Metallic Tubing (FMT):

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Electri-Flex Company.
 - b. International Metal Hose Co.
 - c. Liquid Tight Connector Co.
 - d. Southwire Company.
- 2. Options:
 - a. Minimum Trade Size: trade size 3/4.
 - b. Colors: As indicated on Drawings.

2.9 TYPE IMC RACEWAYS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 1242 and UL Category Control Number DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Calconduit; Atkore International.
 - d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - e. Topaz Lighting & Electric.
 - f. Western Tube; Zekelman Industries.
 - g. Wheatland Tube; Zekelman Industries.
- 2. Options:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc.
 - c. Minimum Trade Size: trade size 3/4.

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- d. Colors: As indicated on Drawings.

2.10 TYPE LFMC RACEWAYS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 360 and UL Category Control Number DXHR.

B. Steel Liquidtight Flexible Metal Conduit (LFMC-S):

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Anaconda Sealtite; Anamet Electrical, Inc.
 - c. Electri-Flex Company.
 - d. International Metal Hose Co.
- 2. Material: Steel.
- 3. Options:
 - a. Minimum Trade Size: trade size 3/4.
 - b. Colors: As indicated on Drawings.

2.11 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 651 and UL Category Control Number DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Calconduit; Atkore International.
 - c. JM Eagle; J-M Manufacturing Co., Inc.
 - d. NAPCO; Westlake Chemical Corp.
 - e. Opti-Com Manufacturing Network, Inc (OMNI).
 - f. Topaz Lighting & Electric.
- 2. Dimensional Specifications: Schedule 40.
- 3. Options:

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- a. Minimum Trade Size: trade size 3/4.
 - b. Markings: For use with maximum 90 deg C wire. For directional boring applications.
- C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:
- 1. Dimensional Specifications: Schedule 80.
 - 2. Options:
 - a. Minimum Trade Size: trade size 3/4.
 - b. Markings: For use with maximum 90 deg C wire. For directional boring applications.
- D. Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:
- 1. Dimensional Specifications: Type EB.
 - 2. Options:
 - a. Minimum Trade Size: trade size 4”.

2.12 FITTINGS FOR CONDUIT, TUBING, AND CABLE

- A. Performance Criteria:
- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- B. Fittings for Type ERMC, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:
- 1. General Characteristics: UL 514B and UL Category Control Number DWTT.
 - 2. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling, Raintight compression coupling with distinctive color gland nut.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.
- C. Fittings for Type EMT Raceways:
- 1. General Characteristics: UL 514B and UL Category Control Number FKAV.
 - 2. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling, Raintight compression coupling with distinctive color gland nut.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

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- D. Fittings for Type FMC Raceways:
 - 1. General Characteristics: UL 514B and UL Category Control Number ILNR.
- E. Fittings for Type LFMC and Type LFNC Raceways:
 - 1. General Characteristics: UL 514B and UL Category Control Number DXAS.

2.13 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: UL 2419 and UL Category Control Number FOIZ.

2.14 SOLVENT CEMENTS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL Category Control Number DWTT.

2.15 SURFACE METAL RACEWAYS AND FITTINGS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: UL 5 and UL Category Control Number RJBT.
- B. Surface Metal Raceways and Fittings with Metal Covers:
 - 1. Options:
 - a. Galvanized steel base with snap-on covers.
 - b. Manufacturer's standard enamel finish in color selected by Architect Prime coated, ready for field painting.
 - c. Wiring Channels: Single, Dual, Triple. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.
- C. Surface Metal Raceways and Fittings with Nonmetallic Covers:

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1. Additional Characteristics: UL 94, V-0 requirements for self-extinguishing characteristics.
2. Options:
 - a. **Galvanized steel** base with snap-on covers.
 - b. Provide texture and color selected by Architect from manufacturer's standard and custom colors.
 - c. Wiring Channels: Single, Dual, Triple. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

2.16 STRUT-TYPE CHANNEL RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 5B and UL Category Control Number RIUU.

B. Strut-Type Channel Raceways and Fittings with Metallic Covers:

1. Options:
 - a. [Manufacturer's standard enamel finish in color selected by Architect] [Prime coated, ready for field painting].

C. Strut-Type Channel Raceways and Fittings with Nonmetallic Covers:

1. Additional Characteristics: UL 94, V-0 requirements for self-extinguishing characteristics.
2. Options:
 - a. Provide texture and color selected by Architect from manufacturer's standard and custom colors.

2.17 WIREWAYS AND AUXILIARY GUTTERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 870 and UL Category Control Number ZOYX.

B. Metal Wireways and Auxiliary Gutters:

1. Additional Characteristics:
 - a. 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.

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- b. Finish: Manufacturer's standard enamel finish.
- 2. Options:
 - a. Degree of Protection: Type 1, Type 3R, unless otherwise indicated.
 - b. Wireway Covers: Hinged type, Flanged-and-gasketed type unless otherwise indicated.

2.18 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 514A and UL Category Control Number QCIT.

B. Metallic Outlet Boxes:

- 1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
- 2. Options:
 - a. Material: Sheet steel.
 - b. Sheet Metal Depth: Minimum 1.5 inch.
 - c. Cast-Metal Depth: Minimum 1.8 inch.
 - d. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing more than 50 lb. and marked with maximum allowable weight.
 - e. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb.

C. Metallic Conduit Bodies:

- 1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Crouse-Hinds; Eaton, Electrical Sector.
 - c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
 - d. Killark; Hubbell Incorporated, Construction and Energy.
 - e. O-Z/Gedney; Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Pass & Seymour; Legrand North America, LLC.
 - g. Patriot Aluminum Products, LLC.
 - h. Plasti-Bond; Robroy Industries.
 - i. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.

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j. Topaz Lighting & Electric.

D. Metallic Device Boxes:

1. Description: Box with provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Arlington Industries, Inc.
 - c. Crouse-Hinds; Eaton, Electrical Sector.
 - d. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
 - e. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
 - f. Killark; Hubbell Incorporated, Construction and Energy.
 - g. O-Z/Gedney; Emerson Electric Co., Automation Solutions, Appleton Group.
 - h. Patriot Aluminum Products, LLC.
 - i. Plasti-Bond; Robroy Industries.
 - j. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - k. Topaz Lighting & Electric.
 - l. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
3. Options:
 - a. Material: Sheet steel.
 - b. Sheet Metal Depth: minimum 1.5 inch.
 - c. Cast-Metal Depth: minimum 1.8 inch.

E. Metallic Extension Rings:

1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. B-line; Eaton, Electrical Sector.
 - c. Crouse-Hinds; Eaton, Electrical Sector.
 - d. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
 - e. O-Z/Gedney; Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Pass & Seymour; Legrand North America, LLC.
 - g. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - h. Topaz Lighting & Electric.
 - i. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

F. Metallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.

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- b. AFC Cable Systems; Atkore International.
- c. Arlington Industries, Inc.
- d. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
- e. FSR Inc.
- f. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
- g. Leviton Manufacturing Co., Inc.
- h. Pass & Seymour; Legrand North America, LLC.
- i. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
- j. Wiremold; Legrand North America, LLC.
- k. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

G. Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

- 1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FSR Inc.
 - b. Wiremold; Legrand North America, LLC.
 - c. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

H. Metallic Concrete Boxes and Covers:

- 1. Description: Box intended for use in poured concrete.
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Crouse-Hinds; Eaton, Electrical Sector.
 - c. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
 - d. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - e. Topaz Lighting & Electric.
 - f. Wiremold; Legrand North America, LLC.

2.19 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 514C and UL Category Control Number QCMZ.

B. Nonmetallic Outlet Boxes:

- 1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables,

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with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Arlington Industries, Inc.
 - d. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - e. Cantex Inc.
 - f. Crouse-Hinds; Eaton, Electrical Sector.
 - g. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
 - h. Ericson Manufacturing Company.
 - i. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
 - j. Intermatic, Inc.
 - k. JM Eagle; J-M Manufacturing Co., Inc.
 - l. Leviton Manufacturing Co., Inc.
 - m. Panduit Corp.
 - n. Pass & Seymour; Legrand North America, LLC.
 - o. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - p. Topaz Lighting & Electric.
 - q. Wiremold; Legrand North America, LLC.
 - r. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

C. Nonmetallic Conduit Bodies:

1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Arlington Industries, Inc.
 - d. Cantex Inc.
 - e. JM Eagle; J-M Manufacturing Co., Inc.
 - f. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - g. Topaz Lighting & Electric.

D. Nonmetallic Device Boxes:

1. Description: Box with provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Arlington Industries, Inc.
 - d. Cantex Inc.
 - e. Crouse-Hinds; Eaton, Electrical Sector.

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- f. Pass & Seymour; Legrand North America, LLC.
- g. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
- h. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

E. Nonmetallic Extension Rings:

- 1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Arlington Industries, Inc.
 - d. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - e. Cantex Inc.
 - f. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - g. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

F. Nonmetallic Floor Boxes and Floor Box Covers:

- 1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Arlington Industries, Inc.
 - d. Cantex Inc.
 - e. JM Eagle; J-M Manufacturing Co., Inc.
 - f. Pass & Seymour; Legrand North America, LLC.
 - g. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - h. Wiremold; Legrand North America, LLC.

G. Nonmetallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

- 1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

H. Nonmetallic Floor Nozzles:

- 1. Description: Enclosure intended primarily as housing for receptacle, provided with means, such as collar, for surface-mounting on floor, which may or may not include stem to support it above floor level, and is sealed against the entrance of scrub water at floor level.

I. Nonmetallic Concrete Boxes and Covers:

- 1. Description: Box intended for use in poured concrete.

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2.20 TERMINATION BOXES

- A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: UL 1773 and UL Category Control Number XCKT.
- C. Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment:
 - 1. Additional Characteristics: Listed and labeled for installation on line side of service equipment.
- D. Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment:
 - 1. Additional Characteristics: Listed and labeled for installation on load side of service equipment.

2.21 CABINETS, CUTOFF BOXES, JUNCTION BOXES, PULL BOXES, AND MISCELLANEOUS ENCLOSURES

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics:
 - a. Non-Environmental Characteristics: UL 50.
 - b. Environmental Characteristics: UL 50E.
- B. Indoor Sheet Metal Cabinets:
 - 1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
 - 2. Additional Characteristics: UL Category Control Number CYIV.
 - 3. Options:
 - a. Degree of Protection: Type 1, Type 12.
- C. Indoor Sheet Metal Cutoff Boxes:
 - 1. Description: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
 - 2. Additional Characteristics: UL Category Control Number CYIV.

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3. Options:
 - a. Degree of Protection: **Type 1.**

- D. Indoor Sheet Metal Junction and Pull Boxes:
 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 2. Additional Characteristics: UL Category Control Number BGUZ.
 3. Options:
 - a. Degree of Protection: Type 1.

- E. Indoor Cast-Metal Junction and Pull Boxes:
 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 2. Additional Characteristics: UL Category Control Number BGUZ.
 3. Options:
 - a. Degree of Protection: Type 1.

- F. Indoor Sheet Metal Miscellaneous Enclosures:
 1. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.
 2. Options:
 - a. Degree of Protection: Type 1.

- G. Outdoor Sheet Metal Cabinets:
 1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
 2. Additional Characteristics: UL Category Control Number CYIV.
 3. Options:
 - a. Degree of Protection: Type 3R.

- H. Outdoor Sheet Metal Cutout Boxes:
 1. Description: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
 2. Additional Characteristics: UL Category Control Number CYIV.
 3. Options:
 - a. Degree of Protection: Type 3R.

- I. Outdoor Sheet Metal Junction and Pull Boxes:

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1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Additional Characteristics: UL Category Control Number BGUZ.
3. Options:
 - a. Degree of Protection: Type 3R.

J. Outdoor Cast-Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Additional Characteristics: UL Category Control Number BGUZ.
3. Options:
 - a. Degree of Protection: Type 3R.

K. Outdoor Sheet Metal Miscellaneous Enclosures:

1. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.
2. Options:
 - a. Degree of Protection: Type 3R.

2.22 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. Reference Standards: UL 514D and UL Category Control Numbers QCIT and QCMZ.
 - b. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Metallic Cover Plates for Device Boxes:

1. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: 0.032 inch thick Type 302/304 non-magnetic stainless steel with brushed finish, Steel with white baked enamel, suitable for field painting 0.04 inch thick steel with chrome-plated finish, Galvanized steel as indicated on architectural Drawings.

C. Nonmetallic Cover Plates for Device Boxes:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Arlington Industries, Inc.
 - c. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - d. Crouse-Hinds; Eaton, Electrical Sector.
 - e. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
 - g. Intermatic, Inc.
 - h. Leviton Manufacturing Co., Inc.
 - i. O-Z/Gedney; Emerson Electric Co., Automation Solutions, Appleton Group.
 - j. Panduit Corp.
 - k. Pass & Seymour; Legrand North America, LLC.
 - l. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
 - m. Topaz Lighting & Electric.
 - n. Wiremold; Legrand North America, LLC.
 - o. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: 0.060 inch thick high-impact thermoplastic (nylon) with smooth finish and color matching wiring device as indicated on architectural Drawings.
 - c. Color: White or as indicated on architectural Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of the raceway system. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRING METHODS

- A. Outdoors: Use 3/4" minimum trade size.
- B. Indoors: use 3/4" minimum trade size except as noted below:
 1. Connection to Vibrating Equipment Light Fixtures: 1/2" trade size minimum.
 2. Connection to Light Fixtures: 1/2" trade size minimum, flexible metal conduit, except in wet or damp locations use Liquid tight flexible metal conduit, or solid connection.
- C. Underground: use 1" minimum trade size.

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3.3 SELECTION OF RACEWAYS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.
- B. Outdoors:
1. Exposed and Subject to Severe Physical Damage: ERM.C.
 2. Exposed and Subject to Physical Damage: ERM. IMC, Corrosion-resistant EMT.
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 3. Exposed and Not Subject to Physical Damage: ERM.C, Corrosion-resistant EMT, PVC-80.
 4. Concealed Aboveground: ERM.C, EMT.
 5. Direct Buried: PVC-80, PVC-40.
 6. Concrete Encased Not in Trench: PVC-80.
 7. Concrete Encased in Trench: PVC-80.
 8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- C. Indoors:
1. Hazardous Classified Locations: ERM.C, IMC.
 2. Exposed and Subject to Severe Physical Damage: ERM.C. Subject to severe physical damage includes the following locations:
 - a. Loading docks.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 3. Exposed and Subject to Physical Damage: ERM.C, IMC, EMT. Subject to physical damage includes the following locations:
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 - b. Stub-ups to above suspended ceilings.
 - c.
 4. Exposed and Not Subject to Physical Damage: ERM.C, EMT, PVC-80.
 5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 6. Damp or Wet Locations: ERM.C, IMC, Corrosion-resistant EMT.

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7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment: LFMC.
- D. Raceway Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
1. ERMIC and IMC: Provide threaded type fittings unless otherwise indicated.

3.4 SELECTION OF BOXES AND ENCLOSURES

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
1. Outdoors:
 - a. Type 3R unless otherwise indicated.
 - b. Locations Exposed to Hosedown: Type 4.
 - c. Locations Subject to Potential Flooding: Type 6P.
 - d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
 - e. Locations in-Ground or Exposed to Corrosive Agents: Type 6P, Type 3RX.
 - f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.
 2. Indoors:
 - a. Type 1 unless otherwise indicated.
 - b. Damp or Dusty Locations: Type 12.
 - c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
 - d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12, Type 12K.
 - e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4, Type 6.
 - f. Locations Exposed to Hosedown: Type 4, Type 6.
 - g. Locations Exposed to Corrosive Agents: Type 4X.
 - h. Locations Exposed to Spraying Oil or Coolants: Type 13.
- C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
1. Provide cast-metal boxes. Boxes with knockouts or unprotected openings are prohibited.
 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.5 INSTALLATION OF RACEWAYS

- A. Installation Standards:

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1. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for installation of raceways. Consult Architect for resolution of conflicting requirements.
 2. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
 3. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
 4. Comply with NECA NEIS 101 for installation of steel raceways.
 5. Comply with NECA NEIS 102 for installation of aluminum raceways.
 6. Comply with NECA NEIS 111 for installation of nonmetallic raceways.
 7. Install raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
 8. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to trade size 1-1/2 and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
 9. Raceway Terminations at Locations Subject to Moisture or Vibration:
 - a. Provide insulating bushings to protect conductors, including conductors smaller than No. 4 AWG. Install insulated throat metal grounding bushings on service conduits.
- B. General Requirements for Installation of Raceways:
1. Complete raceway installation before starting conductor installation.
 2. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft. above finished floor.
 3. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch of changes in direction.
 4. Make bends in raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
 5. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
 6. Support conduit within 12 inch of enclosures to which attached.

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7. Install raceway sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings in accordance with NFPA 70.
 8. 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 interior of raceways at the following points:
 - a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - b. Where an underground service raceway enters a building or structure.
 - c. Conduit extending from interior to exterior of building.
 - d. Conduit extending into pressurized duct and equipment.
 - e. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - f. Where otherwise required by NFPA 70.
 9. Do not install raceways or electrical items on "explosion-relief" walls or rotating equipment.
 10. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
 11. Keep raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
 12. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
 13. Install pull wires in empty raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- C. Requirements for Installation of Specific Raceway Types:
1. Types EMT-A, ERMC-A, and FMC-A:
 - a. Do not install aluminum raceways or fittings in contact with concrete or earth.
 2. Types ERMC and IMC:
 - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
 3. Type ERMC-S-PVC:
 - a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
 - b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMC-S-PVC elbows in direct-burial

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applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMC-S-PVC raceway.

- c. Coat field-cut threads on PVC-coated raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.
 4. Types FMC, LFMC, and LFNC:
 - a. Comply with NEMA RV 3. Provide a maximum of 72 inch of flexible conduit for **recessed and semi recessed luminaires**, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 5. Types PVC and EPEC:
 - a. Do not install Type PVC or Type EPEC conduit where ambient temperature exceeds 122 deg F. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
 - b. Comply with manufacturer's written instructions for solvent welding and fittings.
 6. Type RTRC:
 - a. Do not install Type RTRC conduit where ambient temperature exceeds 230 deg F.
- D. Raceways Embedded in Slabs:
1. Raceways in slabs will only be permitted if structural engineer allows the installation of any sized conduit on the. If allowed contractor will follow Structural Engineers requirements for size and installation.
 2. If allowed run raceways larger than trade size 1 below concrete slab. Run raceways larger than trade size 1 parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place raceway close to slab support. Secure raceways to reinforcement at maximum 10 ft. intervals.
 3. Arrange raceways to cross building expansion joints with expansion fittings at right angles to the joint.
 4. Arrange raceways to ensure that each is surrounded by a minimum of 2 inch of concrete without voids.
 5. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
 6. Change from ENT to ERMC before rising above floor.
- E. Stub-ups to Above Recessed Ceilings:
1. Provide EMT, IMC, or ERMC for raceways. Minimum 4" above slab.
 2. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- F. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

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1. ERMC-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
2. EMT: Provide compression fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

G. Expansion-Joint Fittings:

1. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
2. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 25 deg F temperature change.
 - d. Attics: 135 deg F 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 deg. F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg. F of temperature change for metal conduits.
4. Install expansion fittings at locations where conduits cross building or structure expansion joints.
5. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

H. Raceways Penetrating Rooms or Walls with Acoustical Requirements:

1. Seal raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

3.6 INSTALLATION OF SURFACE RACEWAYS

- A. Install surface raceways only where indicated on Drawings.
- B. Install surface raceway with a minimum 2 inch radius control at bend points.

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- C. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's written instructions. Tape and glue are unacceptable support methods.

3.7 INSTALLATION OF BOXES AND ENCLOSURES

- A. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
- B. 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 top of box unless otherwise indicated.
- C. 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 box and cover plate or supported equipment and box, whether installed indoors or outdoors.
- D. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- E. Locate boxes so that cover or plate will not span different building finishes.
- F. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
- G. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
- H. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
- I. Set metal floor boxes level and flush with finished floor surface.
- J. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- K. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
- L. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
- M. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
 - 1. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
 - 2. Provide gaskets for wallplates and covers.

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3.8 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.9 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer.
- B. 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.

3.10 CLEANING

- A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.
- B. Boxes: Remove construction dust and debris from device boxes, outlet boxes, and floor-mounted enclosures before installing wallplates, covers, and hoods.

END OF SECTION

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**SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND
CABLING**

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve seal systems.
4. Grout.
5. Pourable sealants.
6. Foam sealants.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

- A. Wall Sleeves, Steel:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC.
 - b. CCI Piping Systems.
 - c. Flexicraft Industries.
 - d. GPT; an EnPro Industries company.

No manufacturers available

2. Description: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. Wall Sleeves, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Ductile Iron Pipe.
 - b. Flexicraft Industries.
 - c. McWane Ductile.
2. Description: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

C. Pipe Sleeves, PVC:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CCI Piping Systems.
 - b. GPT; an EnPro Industries company.
 - c. Metraflex Company (The).
2. Description: ASTM D1785, Schedule 40.

D. Molded Sleeves, PVC:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Arlington Industries, Inc.
 - c. Reliance Worldwide Corporation.
2. Description: With nailing flange for attaching to wooden forms.

E. Molded Sleeves, PE or PP:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crete-Sleeve.
2. Description: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

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F. Sheet Metal Sleeves, Galvanized Steel, Round:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Benefast.
 - b. Specified Technologies, Inc.
2. Description: Galvanized-steel sheet; thickness not less than 0.0239 inch; 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Abesco Fire LLC.
 - b. Specified Technologies, Inc.
 - c. Wiremold; Legrand North America, LLC.
2. Description:
 - a. Material: Galvanized sheet steel.
 - b. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inch and with no side larger than 16 inch, thickness must be 0.052 inch.
 - 2) For sleeve cross-section rectangle perimeter not less than 50 inch or with one or more sides larger than 16 inch, thickness must be 0.138 inch.

2.3 SLEEVE SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. BWM Company.
3. CALPICO, Inc.
4. Flexicraft Industries.
5. Metraflex Company (The).
6. Pipeline Seal and Insulator, Inc.
7. Proco Products, Inc.

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- B. 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, Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 GROUT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. W.R. Meadows, Inc.
- B. 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, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

2.5 POURABLE SEALANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carlisle SynTec Incorporated.
 - 2. GAF.
 - 3. Johns Manville; a Berkshire Hathaway company.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:

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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 annular clear space between sleeve and raceway or cable, unless sleeve seal system is to be installed or seismic criteria require different clearance.
 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 4 inch above finished floor level. Install sleeves during erection of floors.
- B. 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.
- C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- E. Underground, Exterior-Wall and Floor Penetrations:
1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve seal system. Install sleeve during construction of floor or wall.
 2. Install steel pipe sleeves. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve seal system. Grout sleeve into wall or floor opening.

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.

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- 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

SECTION 26 0548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraints - rigid type.
2. Restraints - cable type.
3. Restraint accessories.
4. Post-installed concrete anchors.
5. Concrete inserts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 DEFINITIONS

- A. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 COORDINATION

A. Tests and Inspections:

1. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and provide notice at least seven days in advance.
2. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load capacity for each seismic and wind-load restraint device.

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2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic and wind-load restraint component used.
 3. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by an agency acceptable to authorities having jurisdiction.
 4. Annotate to indicate application of each product submitted and compliance with requirements.
- B. Delegated Design Submittal, signed and sealed by qualified structural professional engineer, for Each Seismic-Restraint Device:
1. For each seismic-restraint device, including restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:
 - a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
- C. Delegated Design Submittal: Signed and sealed by qualified structural professional engineer, for each wind-load protection device.
1. For each wind-load protection device, including restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:
 - a. Wind-Load Restraint: Select wind-load restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind loads. Include certification that device is approved by an NRTL for reinforcement use.
 - c. Wind-Load Design Calculations: Submit static and dynamic loading calculations.
 2. Seismic and Wind-Load-Restraint Detail Drawings prepared by qualified structural professional engineer:
 - a. Design Analysis: To support selection and arrangement of seismic and wind-load restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint details with wind-load details required for equipment mounted outdoors.
 3. Product Listing, Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

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1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic and wind-load bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- B. Welding certificates.
- C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by an agency acceptable to authorities having jurisdiction.
- B. Consequential Damage: Provide additional seismic and wind-load restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component does not cause failure of any other essential building component.
- C. Fire/Smoke Resistance: Seismic and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested and labeled by an NRTL in accordance with ASTM E84 or UL 723.
- D. Component Supports:
 - 1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of an NRTL.

2.2 RESTRAINTS - RIGID TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line; Eaton, Electrical Sector.
 - 2. CADDY; nVent.
 - 3. California Dynamics Corporation.
 - 4. Hilti, Inc.
 - 5. Isolation Technology, Inc.

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6. TOLCO.
 7. Unistrut; Atkore International.
 8. Vibration Mountings & Controls, Inc.
- B. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line; Eaton, Electrical Sector.
 2. CADDY; nVent.
 3. Loos & Co.
 4. Vibration Mountings & Controls, Inc.
- B. Seismic and Wind-Load-Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.
- C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.4 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line; Eaton, Electrical Sector.
 2. CADDY; nVent.
 3. Hilti, Inc.
 4. Loos & Co.
 5. Mason Industries, Inc.
 6. TOLCO.

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7. Unistrut; Atkore International.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line; Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.
 - f. Unistrut; Atkore International.
 2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.
- B. Adhesive Anchor Bolts:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line; Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.
 - f. Unistrut; Atkore International.

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2. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
- C. Provide post-installed concrete anchors that have been prequalified for use in seismic and wind-load applications.
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.
- D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.
1. Undercut expansion anchors are permitted.

2.6 CONCRETE INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. B-line; Eaton, Electrical Sector.
 2. Hilti, Inc.
 3. Mason Industries, Inc.
 4. Powers Fasteners.
 5. Simpson Strong-Tie Co., Inc.
 6. Unistrut; Atkore International.
- B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.
- C. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic and wind-load control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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- B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static, wind-load, and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC-RESTRAINT AND WIND-LOAD CONTROL DEVICES

- A. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind-Load Controls Schedule, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
 - 1. Install equipment and devices to withstand the effects of earthquake motions and high wind events.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- C. Installation of seismic and wind-load restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.
- D. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

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2. Install seismic-restraint and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction] that provides required submittals for component.
- F. Equipment and Hanger Restraints:
1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- G. Install cables so they do not bend across edges of adjacent equipment or building structure.
- H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- J. Post-Installed Concrete Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 5. Set anchors to manufacturer's recommended torque using a torque wrench.
 6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different

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structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by Architect and authorities having jurisdiction.
- B. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
 - 3. Test to 90 percent of rated proof load of device.
- C. Seismic controls will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

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SECTION 26 0550 – INSTALLATION COORDINATION

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 REQUIREMENTS

- A. See Division 21, Section 210549, Fire Protection and Electrical Installation Coordination.
- B. See Division 22, Section 220549, Plumbing & Electrical Installation Coordination.
- C. See Division 23, Section 230549, HVAC and Electrical Installation Coordination.
- D. See Mechanical Drawings for control requirements and for items requiring 120V power.

PART 2 - PRODUCTS

- A. Not applicable.

PART 3 - EXECUTION

- A. Not applicable.

END OF SECTION

SECTION 26 0553 - 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. Labels.
 - 2. Bands and tubes.
 - 3. Tapes and stencils.
 - 4. Tags.
 - 5. Signs.
 - 6. Cable ties.
 - 7. Miscellaneous identification products.

1.3 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 electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer's Standard Products: Where more than one type is listed for a specified application, selection is Installer's option, but provide single type for each application category.
- B. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.
- C. Aluminum-Faced Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, laminated with moisture-resistant acrylic adhesive, and punched for the fastener. Preprinted legends suit each application.

2.2 ENGRAVED NAMEPLATES AND SIGNS

- A. Engraved Legend:
 - 1. Normal Power – White letters on black face, unless noted otherwise on Drawings.
 - 2. Emergency Power – White letters on red face, unless noted otherwise on Drawings.
 - 3. UPS Power – White letters on blue face, unless noted otherwise on Drawings.

2.3 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. Comply with NFPA 70E and Section 260573 "Electrical Systems Studies" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.4 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:

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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, feeder, and branch-circuit conductors.
1. Color shall be factory applied[or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit].
 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 208V or gray 480V.
 6. Color for Equipment Grounds: Green.
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- D. Warning Label Colors:
1. Identify system voltage with black letters on an orange background.
- E. 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."
- F. Equipment Identification Labels:
1. Black letters on a white field.

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2.5 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Champion America.
 - c. emedco.
 - d. Grafoplast Wire Markers.
 - e. HellermannTyton.
 - f. LEM Products Inc.
 - g. Marking Services, Inc.
 - h. Panduit Corp.
 - i. Seton Identification Products; a Brady Corporation company.
- B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
 - d. Panduit Corp.
 - e. Seton Identification Products; a Brady Corporation company.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester flexible label with acrylic pressure-sensitive adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. emedco.
 - e. Grafoplast Wire Markers.
 - f. Ideal Industries, Inc.
 - g. LEM Products Inc.
 - h. Marking Services, Inc.
 - i. Panduit Corp.
 - j. Seton Identification Products; a Brady Corporation company.
 2. 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.
 3. Marker for Labels:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.

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- b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.6 BANDS AND TUBES

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
 - d. Panduit Corp.
- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Panduit Corp.

2.7 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.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. HellermannTyton.
 - d. Ideal Industries, Inc.
 - e. Marking Services, Inc.
 - f. Panduit Corp.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.
- C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and are 12 inches wide. Stop stripes at legends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brimar Industries, Inc.
 - b. HellermannTyton.
 - c. LEM Products Inc.
 - d. Marking Services, Inc.
 - e. Seton Identification Products; a Brady Corporation company.
- D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Seton Identification Products; a Brady Corporation company.
- E. Underground-Line Warning Tape:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Ideal Industries, Inc.
 - d. LEM Products Inc.
 - e. Marking Services, Inc.
 - f. Reef Industries, Inc.
 - g. Seton Identification Products; a Brady Corporation company.
 2. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 3. Color and Printing:
 - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".

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- c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
- 4. Tape Type I:
 - a. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Thickness: 4 mils.
 - d. Weight: 18.5 lb/1000 sq. ft..
 - e. Tensile according to ASTM D882: 30 lbf and 2500 psi.
- 5. Tape Type II:
 - a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Thickness: 12 mils.
 - d. Weight: 36.1 lb/1000 sq. ft..
 - e. Tensile according to ASTM D882: 400 lbf and 11,500 psi.
- 6. Tape Type ID:
 - a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Overall Thickness: 5 mils.
 - d. Foil Core Thickness: 0.35 mil.
 - e. Weight: 28 lb/1000 sq. ft..
 - f. Tensile according to ASTM D882: 70 lbf and 4600 psi.
- 7. Tape Type IID:
 - a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Overall Thickness: 8 mils.
 - d. Foil Core Thickness: 0.35 mil.
 - e. Weight: 34 lb/1000 sq. ft..
 - f. Tensile according to ASTM D882: 300 lbf and 12,500 psi.
- F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be **1 inch**.

2.8 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.
 - e. Seton Identification Products; a Brady Corporation company.

- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Grafoplast Wire Markers.
 - e. LEM Products Inc.
 - f. Marking Services, Inc.
 - g. Panduit Corp.
 - h. Seton Identification Products; a Brady Corporation company.

- C. Write-on Tags:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brimar Industries, Inc.
 - b. Carlton Industries, LP.
 - c. LEM Products Inc.
 - d. Seton Identification Products; a Brady Corporation company.

 2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.

 3. Marker for Tags:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.9 SIGNS

- A. Baked-Enamel Signs:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. emedco.
 - d. Marking Services, Inc.

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2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
 3. 1/4-inch grommets in corners for mounting.
 4. Nominal Size: 7 by 10 inches.
- B. Metal-Backed Butyrate Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Champion America.
 - c. emedco.
 - d. Marking Services, Inc.
 2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
 3. 1/4-inch grommets in corners for mounting.
 4. Nominal Size: 10 by 14 inches.
- C. Laminated Acrylic or Melamine Plastic Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.
 2. Engraved legend.
 3. Thickness:
 - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
 - b. For signs larger than 20 sq. in., 1/8 inch thick.
 - c. Engraved legend with black letters on white face.
 - d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.10 CABLE TIES

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

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2. Ideal Industries, Inc.
 3. Marking Services, Inc.
 4. Panduit Corp.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black, except where used for color-coding.
- C. 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.
 2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black.
- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 Deg F according to ASTM D638: 7000 psi.
 3. UL 94 Flame Rating: 94V-0.
 4. Temperature Range: Minus 50 to plus 284 deg F.
 5. Color: Black.

2.11 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.

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PART 3 - EXECUTION

3.1 PREPARATION

- A. 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.

3.2 INSTALLATION

- A. Identify feeders over 600 V labeled with “DANGER—HIGH VOLTAGE” with black letters 2 inches high, stenciled with paint at 10-foot intervals over a continuous, painted orange background. Identify the following:
1. Entire surface of exposed conduits.
- B. Install painted identification as follows:
1. Clean surfaces of dust, loose material, and oily films before painting.
 2. Prime Surfaces: For galvanized metal, use single-component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty, acrylic-resin block filler. For concrete surfaces, use clear, alkali-resistant, alkyd binder-type sealer.
 3. Apply one intermediate and one finish coat of silicone alkyd enamel.
 4. Apply primer and finish materials according to manufacturer’s instructions.
 - a. Identify Raceways and Exposed Cables with Color Banding: Band exposed and accessible raceways of the systems listed below for identification.
 5. Colors: As follows:
 - a. 120/208 Volt – Black
 - b. 277/480 Volt – Blue
 - c. Emergency 120/208 Volt – Black and Orange
 - d. Emergency 277/480 Volt – Blue and Orange
 - e. Fire-Alarm System – Red
 - f. Fire-Suppression Supervisory and Control System – Red and Yellow
 - g. Combined Fire-Alarm and Security System – Red and Blue
 - h. Security System – Blue and Yellow
 - i. Mechanical and Electrical Supervisory System – Green and Blue
 6. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 7. Concealed Boxes: Plasticized cardstock tags.
 8. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

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C. Color-Code Conductors:

1. 208/120-V System: As follows:
 - a. Neutral – White
 - b. Ground – Green
2. 480-277-V System: As follows;
 - a. Neutral – Grey
 - b. Ground – Green
3. Factory-apply color the entire length of the conductors, except the following field-applied, color-coding methods may be used in lieu of factory-coded wire for phase conductors sizes larger than No. 10 AWG and grounded conductors and grounding conductors larger than No. 6 AWG.
 - a. Colored cable ties applied in groups of 3 ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.
4. Power Circuit Identification: Fasten bands using integral ears.

D. Apply identification to conductors as follows:

1. Conductors to be Extended in the Future: Indicate circuit numbers.
2. Multiple Power or Lighting Circuits in the same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color coding for voltage and phase indication of secondary circuit.
3. Multiple control and Communications Circuits in the same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color coding, or cable marking tape.

E. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
2. Emergency-Operating Signs: Install engraved laminate signs.

F. Install identification as follows:

1. Use white lettering on black field.

Example: Panel 1H1 208Y/120V, 3-ph, 4-wire fed from Panel MDR-CCT#4

- a. Switches and receptacles.

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- b. Rectifiers.
 - c. Frequency converters.
 - d. Telephone switching equipment.
 - e. Clock/program master equipment.
 - f. Call system master station.
 - g. TV/audio monitoring master station.
 - h. Fire-alarm master station or control panel.
 - i. Security-monitoring master station or control panel.
2. Circuits: Apply identification labels of engraved plastic laminate on each switch and receptacle indicating panelboard and circuit number supplying receptacle.
- G. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.
- H. 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.
- I. Install identifying devices before installing acoustical ceilings and similar concealment.
- J. Verify identity of each item before installing identification products.
- K. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- L. Apply identification devices to surfaces that require finish after completing finish work.
- M. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- N. 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.
- O. 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.
- P. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- Q. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- R. Vinyl Wraparound Labels:

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1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- S. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- T. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
- U. Self-Adhesive Labels:
1. On each item, 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-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
- V. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- W. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- X. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- Y. 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 where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- Z. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- AA. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- BB. Underground Line Warning Tape:
1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
 2. Limit use of underground-line warning tape to direct-buried cables.
 3. Install underground-line warning tape for direct-buried cables and cables in raceways.

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CC. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized, plenum-rated, cable ties.

DD. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized, plenum-rated, cable ties.

EE. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized, plenum-rated, cable ties.

FF. Baked-Enamel Signs:

1. Attach signs 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-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

GG. Metal-Backed Butyrate Signs:

1. Attach signs 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-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

HH. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs 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-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

II. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

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3.3 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. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch-high, black letters on 20-inch centers.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.
- D. Accessible Raceways more Than 600 V: Vinyl wraparound labels.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- E. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, more than 20A and 120V to Ground: Identify with self-adhesive raceway labels with vinyl tape applied in bands.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- F. 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."
 - 2. in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.
- H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes labels with the conductor designation.
- I. Conductors to Be Extended in the Future: Attach write-on tags, marker tape, to conductors and list source.
- J. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

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1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- L. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive 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. Power-transfer switches.
 - b. Controls with external control power connections.
- P. Arc Flash Warning Labeling: Self-adhesive labels.
- Q. Operating Instruction Signs: Self-adhesive labels.
- R. Equipment Identification Labels:
1. Indoor Equipment: Self-adhesive label Laminated acrylic or melamine plastic sign.
 2. Outdoor Equipment: Laminated acrylic or melamine sign 4 inches high.
 3. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.

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- b. Enclosures and electrical cabinets.
- c. Access doors and panels for concealed electrical items.
- d. Switchboards.
- e. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
- f. Enclosed switches.
- g. Enclosed circuit breakers.
- h. Enclosed controllers.
- i. Variable-speed controllers.
- j. Push-button stations.
- k. Contactors.
- l. Remote-controlled switches, dimmer modules, and control devices.
- m. Monitoring and control equipment.

END OF SECTION

SECTION 26 0573 - ELECTRICAL SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Short-circuit study.
2. Overcurrent protective device coordination study.
3. Load-flow and voltage-drop study.
4. Motor-starting study.
5. Arc-flash hazard study.
6. Digital-twin modeling.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 DEFINITIONS

- A. Digital Twin: The digital representation of a real-world entity, concept, or notion, either physical or perceived.

1.3 ACTION SUBMITTALS

A. Product Data: For power system analysis software to be used for studies.

1. Product Certificates: For power system study software applications, include certificate stating compliance with specified requirements, signed by software manufacturer.

B. Power System Study Reports:

1. All studies will be incorporated into the gear submittal for, but not limited to Switchboards and panelboards. Electrical gear will not be reviewed without the incorporation of the coordination and other studies needed to provide a complete gear submittal.

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2. Submit reports after approval of system protective devices submittals. Submittals must be in digital form.
 3. Submit short-circuit study input data, including completed computer-program input data sheets.
 4. Submit coordination study input data, including completed computer-program input data sheets.
 - a. Submit load-flow, voltage-drop, and motor-starting data with coordination study.
 5. Submit arc-flash study input data, including completed computer-program input data sheets.
 6. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 7. Submit revised one-line diagram, reflecting field investigation results and results of short-circuit study.
- C. Data files for studies in format compatible with Owner's power system analysis software.
- D. Digital-twin models.

1.4 QUALITY ASSURANCE

- A. Submittals for power system studies must be signed and sealed by qualified electrical professional engineer responsible for their preparation.
- B. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.
- C. Software algorithms must comply with requirements of standards and guides specified in this Section.
- D. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

- A. Standard Features:
 1. Power System Analysis:
 - a. Power-systems-analysis software applications must have analytical capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 3002 series standards.

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- b. Computer software application must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.
 - c. Computer software application must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.
2. Analysis Standards:
- a. Short-Circuit Current Analysis: In accordance with IEEE 3002.3.
 - b. Device Coordination Analysis: In accordance with IEEE 3004.3 and IEEE 3004.5.
 - c. Load-Flow Analysis: In accordance with IEEE 3002.2.
 - d. Motor-Starting Analysis: In accordance with IEEE 3002.7.
 - e. Harmonic Analysis: In accordance with IEEE 3002.8.
 - f. Transient Stability Analysis: In accordance with IEEE P3002.9.
 - g. Arc-Flash Hazard Analysis: In accordance with IEEE 1584.
3. Capable of printing arc-flash hazard warnings for equipment on polyester, weather- and UV-resistant, pressure-sensitive adhesive labels complying with NFPA 70E.
- a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard study:
 - 1) Equipment designation.
 - 2) Nominal voltage.
 - 3) Protection boundaries.
 - a) Arc-flash boundary.
 - b) Restricted approach boundary.
 - c) Limited approach boundary.
 - 4) Arc-flash PPE category.
 - 5) Required minimum arc rating of PPE in Cal/cm squared.
 - 6) Available incident energy.
 - 7) Working distance.
 - 8) Engineering report number, revision number, and issue date.
- B. Other Available Features Required by the Project:
- 1. Simultaneous faults.
 - 2. Explicit negative sequence.
 - 3. Mutual coupling in zero sequence.
 - 4. Digital-Twin Model: Ability to create a cloud-based, digital-twin model for life-cycle operation and maintenance of the facility's electrical power system.

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PART 3 - EXECUTION

3.1 EXAMINATION

- A. Collect and analyze data for power system studies.
1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Architect's attention.
 2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
 3. For relocated equipment and equipment that is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers in accordance with NFPA 70E.
 4. Gather and tabulate required input data to support power system studies. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 3002 series standards as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:
 - a. Product data for the Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - b. Electrical power utility impedance at service.
 - c. Power sources and ties.
 - d. Short-circuit current at each system bus (three phase and line to ground).
 - e. Full-load current of loads.
 - f. Voltage level at each bus.
 - g. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 - h. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 - i. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 - j. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 - k. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
 - l. Maximum demands from service meters.
 - m. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 - n. Motor horsepower and NEMA MG 1 code letter designation.
 - o. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).

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- p. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
- q. Derating factors.

3.2 PREPARATION

A. Preparation of Data for Short-Circuit Study:

- 1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Architect's attention.
- 2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
- 3. Prepare one-line diagram of modeled power system, showing the following:
 - a. Protective device designations and ampere ratings.
 - b. Conductor types, sizes, and lengths.
 - c. Transformer kVA and voltage ratings.
 - d. Motor and generator designations and kVA ratings.
 - e. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
 - f. Derating factors and environmental conditions.
 - g. Revisions to electrical equipment required by study.

B. Preparation of Data for Overcurrent Protective Device Coordination Study:

- 1. Prepare data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, indicating the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Generator thermal-damage curve.
 - e. Ratings, types, and settings of utility company's overcurrent protective devices.
 - f. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
 - k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device

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data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

2. Examine the Project's overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 3. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.
- C. Preparation of Data for Arc-Flash Hazard Study:
1. Assemble data from short-circuit study and overcurrent protective device coordination study.
 2. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.3 SHORT-CIRCUIT STUDY

- A. Base study on device characteristics supplied by device manufacturer.
- B. Extent of electrical power system to be studied is indicated on Drawings.
- C. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:
 1. To normal system low-voltage load buses where fault current is 5 kA or less.
 2. Exclude equipment supplied by single transformer smaller than 45 kVA.
- D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- E. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement to address asymmetrical requirements of interrupting equipment.
- F. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.
 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
- G. Include in report identification of protective device applied outside its capacity.

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3.4 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

- A. Base study on device characteristics supplied by device manufacturer. When analysis of full range of device is impractical, limiting scope of analysis from 10 to 100 percent of device range is acceptable.
- B. Extent of electrical power system to be studied is indicated on Drawings.
- C. Begin analysis at service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 5 kA or less.
- D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- E. Transformer Primary Overcurrent Protective Devices:
 - 1. Device must not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads in accordance with IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings must protect transformers in accordance with IEEE C57.12.00, for fault currents.
- F. Motor Protection:
 - 1. Select protection for low-voltage motors in accordance with IEEE 3004.8 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V in accordance with IEEE 620.
- G. Conductor Protection: Protect cables against damage from fault currents in accordance with ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 3004.7. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- H. Generator Protection: Select protection in accordance with manufacturer's published instructions and IEEE C37.102.
- I. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement, to address asymmetrical requirements of interrupting equipment.
- J. Include coordination of ground-fault protection devices.

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- K. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
- L. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
 - 3. Application of series-rated devices must be recertified, complying with requirements in NFPA 70.
 - 4. Include in report identification of protective device applied outside its capacity.

3.5 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform load-flow and voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:
 - 1. Determine load flow and voltage drop based on full-load currents.
 - 2. Determine load flow and voltage drop based on 80 percent of design capacity of load buses.
 - 3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.6 MOTOR-STARTING STUDY

- A. Perform motor-starting study to analyze transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze effects of motor starting on power system stability.
- B. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 1453, and voltage sags so as not to affect operation of other utilization equipment on system supplying motor.

3.7 ARC-FLASH HAZARD STUDY

- A. Comply with NFPA 70E, including Annex D, for arc-flash hazard study.
- B. Preparatory Studies: Obtain short-circuit study and overcurrent protective device coordination study results prior to starting arc-flash hazard study.

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- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
 - 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
 - 3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.
 - 4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.
- D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations[, except nominal arc-flash hazard warning data may be provided for equipment fed from transformers rated below 240 V(ac), 2000 A, instead of documenting precise calculations].
- F. Calculate limited, restricted, and prohibited approach boundaries for each location.
- G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must account for changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:
 - 1. Fault contribution from induction motors must not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).
- H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:
 - 1. When circuit breaker is in separate enclosure.
 - 2. When line terminals of circuit breaker are separate from work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.8 POWER SYSTEM STUDY REPORTS

- A. Preparation of Power System Study Reports: Prepare and submit the following:

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1. Short-Circuit Study Report Contents:
 - a. Executive summary of study findings.
 - b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
 - c. One-line diagram of modeled power system, showing the following:
 - 1) Protective device designations and ampere ratings.
 - 2) Conductor types, sizes, and lengths.
 - 3) Transformer kVA and voltage ratings.
 - 4) Motor and generator designations and kVA ratings.
 - 5) Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
 - 6) Derating factors and environmental conditions.
 - 7) Revisions to electrical equipment required by study.
 - d. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.
 - e. Short-Circuit Study Input Data:
 - 1) One-line diagram of system being studied.
 - 2) Power sources available.
 - 3) Manufacturer, model, and interrupting rating of protective devices.
 - 4) Conductors.
 - 5) Transformer data.
 - f. Protective Device Evaluation:
 - 1) Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
 - 2) Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 - 3) For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 - 4) For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
 - 5) Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 - g. Short-Circuit Study Output Reports:
 - 1) Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a) Voltage.
 - b) Calculated fault-current magnitude and angle.
 - c) Fault-point X/R ratio.
 - d) Equivalent impedance.
 - 2) Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a) Voltage.
 - b) Calculated symmetrical fault-current magnitude and angle.
 - c) Fault-point X/R ratio.

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- d) Calculated asymmetrical fault currents based on fault-point X/R ratio; based on calculated symmetrical value multiplied by 1.6; and based on calculated symmetrical value multiplied by 2.7.
 - 3) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a) Voltage.
 - b) Calculated symmetrical fault-current magnitude and angle.
 - c) Fault-point X/R ratio.
 - d) No AC Decrement (NACD) ratio.
 - e) Equivalent impedance.
 - f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
 - g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.
2. Overcurrent Protection Device Coordination Study Report Contents:
- a. Executive summary of study findings.
 - b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
 - c. One-line diagram of modeled power system, showing the following:
 - 1) Protective device designations and ampere ratings.
 - 2) Conductor types, sizes, and lengths.
 - 3) Transformer kVA and voltage ratings.
 - 4) Motor and generator designations and kVA ratings.
 - 5) Switchgear, switchboard, motor-control center, and panelboard designations.
 - 6) Revisions to electrical equipment required by study.
 - d. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.
 - 1) Phase and Ground Relays:
 - a) Device tag.
 - b) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - c) Recommendations on improved relaying systems, if applicable.
 - 2) Circuit Breakers:
 - a) Adjustable pickups and time delays (long time, short time, and ground).
 - b) Adjustable time-current characteristic.
 - c) Adjustable instantaneous pickup.
 - d) Recommendations on improved trip systems, if applicable.
 - 3) Fuses: Show current rating, voltage, and class.
 - e. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:
 - 1) Device tag and title, one-line diagram with legend identifying portion of system covered.

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- 2) Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
 - 3) Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 - 4) Plot the following listed characteristic curves, as applicable:
 - a) Power utility's overcurrent protective device.
 - b) Medium-voltage equipment overcurrent relays.
 - c) Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - d) Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - e) Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f) Cables and conductors damage curves.
 - g) Ground-fault protective devices.
 - h) Motor-starting characteristics and motor damage points.
 - i) Generator short-circuit decrement curve and generator damage point.
 - j) Largest feeder circuit breaker in each motor-control center and panelboard.
 - 5) Maintain selectivity for tripping currents caused by overloads.
 - 6) Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
 - 7) Provide adequate time margins between device characteristics such that selective operation is achieved.
 - 8) Comments and recommendations for system improvements.
3. Arc-Flash Hazard Study Report Contents:
- a. Executive summary of study findings.
 - b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
 - c. One-line diagram, showing the following:
 - 1) Protective device designations and ampere ratings.
 - 2) Conductor types, sizes, and lengths.
 - 3) Transformer kVA and voltage ratings, including derating factors and environmental conditions.
 - 4) Motor and generator designations and kVA ratings.
 - 5) Switchboard, panelboard designations, and ratings.
 - d. Short-circuit study output data.
 - e. Overcurrent protective device coordination study report contents.
 - f. Arc-Flash Study Output Reports:
 - 1) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:
 - a) Voltage.
 - b) Calculated symmetrical fault-current magnitude and angle.
 - c) Fault-point X/R ratio.
 - d) No AC Decrement (NACD) ratio.
 - e) Equivalent impedance.
 - f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
 - g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

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- g. Incident Energy and Flash Protection Boundary Calculations:
 - 1) Arcing fault magnitude.
 - 2) Protective device clearing time.
 - 3) Duration of arc.
 - 4) Arc-flash boundary.
 - 5) Restricted approach boundary.
 - 6) Limited approach boundary.
 - 7) Working distance.
 - 8) Incident energy.
 - 9) Hazard risk category.
 - 10) Recommendations for arc-flash energy reduction.
- h. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

3.9 DIGITAL-TWIN MODELING

- A. **Create cloud-based**, digital-twin model of as-constructed facility's electrical power system.

3.10 FIELD ADJUSTMENT FOR DEVICE COORDINATION

- A. Adjust relay and protective device settings in accordance with recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting must be by qualified medium-voltage and low-voltage electrical testing and inspecting agency.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

3.11 WARNING LABELING OF ARC-FLASH HAZARDS

- A. Apply one arc-flash label on front cover of each section of equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in study, including each piece of equipment listed below:
 - 1. Switchboards.
 - 2. Panelboards.
 - 3. Low voltage transformers.
 - 4. Safety switches.

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5. Control panels.
 - B. Base arc-flash label data on highest values calculated at each location.
 - C. Machine print warning labels with no handwritten or field-applied markings.
 - D. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.
 - E. Indicate on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.
 1. Indicate arc-flash energy.
 2. Indicate protection level required.

END OF SECTION

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SECTION 26 2413 - SWITCHBOARDS

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. Service and distribution switchboards rated 600 V and less.
- 2. Surge protection devices.
- 3. Disconnecting and overcurrent protective devices.
- 4. Instrumentation.
- 5. Control power.
- 6. Accessory components and features.
- 7. Identification.
- 8. Mimic bus.

- B. Related Requirements

- 1. Section 260573 "Electrical Systems Studies" for arc-flash analysis and arc-flash label requirements.

1.3 ACTION SUBMITTALS

- A. All studies will be incorporated into the gear submittal for, but not limited to Switchboards and panelboards. Electrical gear will not be reviewed without the incorporation of the coordination and other studies needed to provide a complete gear submittal.
- B. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
 - 1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

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- C. Shop Drawings: For each switchboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 - 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - 6. Detail utility company's metering provisions with indication of approval by utility company.
 - 7. Include evidence of NRTL listing for series rating of installed devices.
 - 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 - 10. Include diagram and details of proposed mimic bus.
 - 11. Include schematic and wiring diagrams for power, signal, and control wiring.
- D. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- E. Delegated Design Submittal:
 - 1. For arc-flash hazard analysis.
 - 2. For arc-flash labels.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

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2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Routine maintenance requirements for switchboards and all installed components.
 - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.

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6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Testing Agency Qualifications: Accredited by NETA.
 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section). Connect factory-installed space heaters to temporary electrical service to prevent condensation. This will be for any switchboard installed exterior to the building.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 1. Do not deliver or install switchboards until spaces are enclosed and weather tight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.
- C. Unusual Service Conditions: NEMA PB 2, as follows:
 1. Ambient temperatures within limits specified.
 2. Altitude not exceeding 6600 feet.
- D. 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:

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1. Notify **Architect** 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 Architect's, Construction Manager's, and Owner's written permission.
4. Comply with NFPA 70E.

1.10 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

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2.2 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Schneider Electric USA (Square D)
 - 2. Siemens Industry, Inc., Energy Management Division
 - 3. Eaton.
 - 4. ABB (Electrification Products Division).
- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. 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.
- E. Comply with NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.
- H. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- I. Nominal System Voltage: 480Y/277V and 208Y/120V.
- J. Main-Bus Continuous: up to 2400A. Or as noted on drawings.
- K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

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- L. Indoor Enclosures: Steel, NEMA 250, Type 1.
- M. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- N. Outdoor Enclosures: Type 3R.
 - 1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
 - 2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.
 - 3. Doors: Personnel door at each end of aisle, minimum width of 36 inches opening outwards; with panic hardware and provisions for cylinder lock. At least one door shall be sized to permit the largest single switchboard section to pass through without disassembling doors, hinges, or switchboard section.
 - 4. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
- O. Barriers: Between adjacent switchboard sections.
- P. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- Q. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - 1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
 - 2. Space-Heater Power Source: 120-V external branch circuit.
- R. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.
- S. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- T. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- U. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- V. Pull Box on Top of Switchboard:

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1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 2. Set back from front to clear circuit-breaker removal mechanism.
 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- W. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
 2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
 3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 4. Copper feeder circuit-breaker line connections.
 5. Tin-plated aluminum feeder circuit-breaker line connections.
 6. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 7. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
 8. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 9. Disconnect Links:
 - a. Isolate neutral bus from incoming neutral conductors.
 - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
 10. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

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- 11. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
- 12. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- X. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- Y. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- Z. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.3 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Schneider Electric USA (Square D)
 - 2. Siemens Industry, Inc., Energy Management Division
 - 3. Eaton
 - 4. Advanced Protection Technologies Inc. (APT)
 - 5. ABB (Electrification Products Division).
- B. SPDs: Comply with UL 1449, Type 1.
- C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.
- D. Features and Accessories:
 - 1. Integral disconnect switch.
 - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Indicator light display for protection status.
 - 4. Form-C contacts rated at 2 A and 24-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 5. Surge counter.

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- E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 2400 V for 480Y/277 V, 700 V for 208Y/120 V.
 - 2. Line to Ground: 1200 V for 480Y/277 V, 1200 V for 208Y/120 V.
 - 3. Line to Line: 2400 V for 480Y/277 V, 1000 V for 208Y/120 V.
- G. SCCR: Equal or exceed 200 kA.
- H. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long and short time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 - 6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 - 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 8. MCCB Features and Accessories:

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- a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching LED lighting loads;
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Time adjustments for long- and short-time pickup.
 - c. Ground-fault pickup level, time delay, and I squared t response.
 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 5. Remote trip indication and control.
 6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 8. Control Voltage: 120-V ac.
- C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Schneider Electric USA (Square D)
 - b. Siemens Industry, Inc., Energy Management Division
 - c. Eaton.
 - d. Boltswitch, Inc.
 2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
 - b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
 5. Service-Rated Switches: Labeled for use as service equipment.
 6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
 - a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
 - c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
 - d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
 7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- E. Fuses are specified in Section 262813 "Fuses."

2.5 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, double secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; bushing type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

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3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
 - d. Megawatts: Plus or minus 1 percent.
 - e. Megavars: Plus or minus 1 percent.
 - f. Power Factor: Plus or minus 1 percent.
 - g. Frequency: Plus or minus 0.1 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- C. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
- D. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
- E. Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
- F. Watt-Hour Meters and Wattmeters:
1. Comply with ANSI C12.1.
 2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
 3. Suitable for connection to three- and four-wire circuits.

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4. Potential indicating lamps.
 5. Adjustments for light and full load, phase balance, and power factor.
 6. Four-dial clock register.
 7. Integral demand indicator.
 8. Contact devices to operate remote impulse-totalizing demand meter.
 9. Ratchets to prevent reverse rotation.
 10. Removable meter with drawout test plug.
 11. Semiflush mounted case with matching cover.
 12. Appropriate multiplier tag.
- G. Impulse-Totalizing Demand Meter:
1. Comply with ANSI C12.1.
 2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
 3. Cyclometer.
 4. Four-dial, totalizing kilowatt-hour register.
 5. Positive chart drive mechanism.
 6. Capillary pen holding a minimum of one month's ink supply.
 7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
 8. Capable of indicating and recording 30-minute integrated demand of totalized system.

2.6 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Control Circuits: 120-V ac, supplied from remote branch circuit.
- C. Control Circuits: 24V dc.
- D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

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- E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.
- F. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.8 IDENTIFICATION

- A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
 - 1. Nameplate: At least 0.032-inch-thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.
- B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
 - 1. Nameplate: At least 0.0625-inch-thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.
- C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

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- D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
 - 1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
 - 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
 - 3. Protect from moisture, dust, dirt, and debris during storage and installation.
 - 4. Install temporary heating during storage per manufacturer's instructions.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

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3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 5. Install anchor bolts to elevations required for proper attachment to switchboards.
 6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- F. Install filler plates in unused spaces of panel-mounted sections.
- G. Install overcurrent protective devices, surge protection devices, and instrumentation.
1. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install spare-fuse cabinet.
- I. Comply with NECA 1.

3.3 CONNECTIONS

- A. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.
- B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- C. Support and secure conductors within the switchboard according to NFPA 70.
- D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

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3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. Tests and Inspections:
 - 1. Acceptance Testing:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
 - b. Test continuity of each circuit.
 - 2. Test ground-fault protection of equipment for service equipment per NFPA 70.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 5. Perform the following infrared scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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- 6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Switchboard will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Electrical Systems Studies".

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

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SECTION 26 2416 - PANELBOARDS

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. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers.

1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. SPD: Surge protective device.
- G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. All studies will be incorporated into the gear submittal for, but not limited to Switchboards and panelboards. Electrical gear will not be reviewed without the incorporation of the coordination and other studies needed to provide a complete gear submittal
- B. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.

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2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- C. Shop Drawings: For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details.
 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 4. Detail bus configuration, current, and voltage ratings.
 5. Short-circuit current rating of panelboards and overcurrent protective devices.
 6. Include evidence of NRTL listing for series rating of installed devices.
 7. Include evidence of NRTL listing for SPD as installed in panelboard.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 9. Include wiring diagrams for power, signal, and control wiring.
 10. Key interlock scheme drawing and sequence of operations.
 11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

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2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

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. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 EXTRA MATERIALS

- A. Touch-Up Paint: One half pint container for enclosures and fronts.

1.9 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.11 FIELD CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.

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- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.
- C. 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 Architect no fewer than Seven days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Architect's, and Owner's written permission.
 - 3. Comply with NFPA 70E.

1.12 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
 - 1. Panelboard Warranty Period: 18 months from date of Substantial Completion.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
 - 1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards 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 a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.
- F. Enclosures: Surface-mounted, dead-front cabinets.

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1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Kitchen, Wash-Down Areas: NEMA 250, Type 4X.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 2. Height: 84 inches maximum.
 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
 5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 7. Finishes:
 - a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
- G. Incoming Mains:
1. Location: Convertible between top and bottom.
 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- H. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

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4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
 6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
 7. Split Bus: Vertical buses divided into individual vertical sections.
 8. <Insert optional features>.
- I. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Terminations shall allow use of 75 deg C rated conductors without de-rating.
 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
 5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
 6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
 9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

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- K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
 - 1. Percentage of Future Space Capacity: 20 percent.
- L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
 - 1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 - 2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.
- M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
 - 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 - 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Schneider Electric USA (Square D)
 - 2. Siemens Industry, Inc., Energy Management Division
 - 3. Eaton.

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4. ESL Power Systems, Inc
 5. Mersen USA.
 6. ABB (Electrification Products Division).
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.
- G. Branch Overcurrent Protective Devices: Fused switches.
- H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 2. External Control-Power Source: 24-V control circuit>.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Schneider Electric USA (Square D).
 2. Siemens Industry, Inc., Energy Management Division.
 3. Eaton.
 4. Bender Inc / Isotrol.
 5. ABB (Electrification Products Division).
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker and or lugs only.
- D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

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- E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 - 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 - 2. External Control-Power Source: 24-V control circuit.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- G. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.
- H. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.
 - 1. Doors: Concealed hinges secured with multipoint latch with tumbler lock; keyed alike.

2.5 LOAD CENTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Schneider Electric USA (Square D)
 - 2. Siemens Industry, Inc., Energy Management Division
 - 3. Eaton.
 - 4. ABB (Electrification Products Division).
- B. Load Centers: Comply with UL 67.
- C. Mains: Circuit breaker and or lugs only.
- D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges secured with flush latch with tumbler lock; keyed alike.
- F. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Schneider Electric USA (Square D).

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2. Siemens Industry, Inc., Energy Management Division.
 3. Eaton.
 4. ABB (Electrification Products Division).
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.
 - 4) Ground-fault pickup level, time delay, and I squared T response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 8. Subfeed Circuit Breakers: Vertically mounted.
 9. Molded-Case Circuit Breaker
 - a. Circuit Breakers, 200 A and Larger: Trip units interchangeable within frame size.
 - b. Circuit Breakers, 400 A and Larger: Field-adjustable short-time and continuous current settings

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- c. Current Limiters: Where indicated, integral fuse listed for circuit breaker.
10. MCCB Features and Accessories:
- a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application; Type SWD for switching LED lighting loads circuits.
 - f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - g. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system. .
 - h. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - i. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
 - j. Rating Plugs: Three-pole breakers with ampere ratings greater than **150** amperes shall have interchangeable rating plugs or electronic adjustable trip units.
 - k. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - l. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - m. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - n. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
 - o. Multipole units enclosed in a [single housing with a single handle] [or] [factory assembled to operate as a single unit].
 - p. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - q. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- 1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
 - 2. Fused Switch Features and Accessories:
 - a. Standard ampere ratings and number of poles.
 - b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.
 - c. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

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2.7 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
- D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NEMA PB 1.1.
- D. Equipment Mounting:
 - 1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
 - 3. Comply with requirements for seismic control devices specified in Section 260548 "Seismic Controls for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- G. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- H. Mount panelboard cabinet plumb and rigid without distortion of box.
- I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.
- K. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- M. Install filler plates in unused spaces.

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- N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- P. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

- A. Labels for identifying the breakers shall be engraved laminated plastic strips attached by screws or Phenolic buttons or small window frame type. Adhesive stick-on labels will not be acceptable.
- B. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- C. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- D. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- F. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:

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1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Electrical System Studies."
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 1. Measure loads during period of normal facility operations.
 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

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Consider the following:

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.7 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

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SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Hospital-grade straight-blade receptacles.
5. Receptacles with arc-fault and ground-fault protective devices.
6. Locking receptacles.
7. Pin-and-sleeve receptacles.
8. Special-purpose power outlet assemblies.
9. Connectors, cords, and plugs.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.

1.2 ALLOWANCES

- A. See Section 012100 "Allowances" for description of allowances affecting items specified in this Section.

1.3 UNIT PRICES

- A. See Section 012200 "Unit Prices" for description of unit prices affecting items specified in this Section.

1.4 ALTERNATES

- A. See Section 012300 "Alternates" for description of alternates affecting items specified in this Section.

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1.5 DEFINITIONS

- A. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.
- B. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

1.6 PREINSTALLATION MEETINGS

- A. Pre-installation Conference: Conduct conference at Project site.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrant(s) for field tests and inspections. Notify Architect, and Owner's Commissioning Authority of scheduled meeting dates.

1.7 ACTION SUBMITTALS

- A. Product Data:
 - 1. Toggle switches.
 - 2. Key lock switches.
 - 3. Maintained-contact switches.
 - 4. Momentary-contact switches.
 - 5. Rocker switches.
 - 6. Dimmer switches.
 - 7. Fan-speed controllers.
 - 8. Single straight-blade receptacles
 - 9. Duplex straight-blade receptacles.
 - 10. Duplex straight-blade receptacles with integral switching means.
 - 11. Receptacles with AFCI and GFCI devices.
 - 12. Locking receptacles.
 - 13. Pin-and-sleeve receptacles.
 - 14. Cord connectors.
- B. Shop Drawings:

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1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

C. Samples:

1. One for each kind of toggle switch and cover plate accessory specified, in each finish and color specified.
2. One for each kind of key lock switch and cover plate accessory specified, in each finish and color specified.
3. One for each kind of maintained-contact switch and cover plate accessory specified, in each finish and color specified.
4. One for each kind of momentary-contact switch and cover plate accessory specified, in each finish and color specified.
5. One for each kind of rocker switch and cover plate accessory specified, in each finish and color specified.
6. One for each kind of dimmer switch and cover plate accessory specified, in each finish and color specified.
7. One for each kind of fan-speed controller switch and cover plate accessory specified, in each finish and color specified.
8. One for each kind of single straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
9. One for each kind of duplex straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
10. One for each kind of duplex straight-blade receptacle with integral switching means and cover plate accessory specified, in each finish and color specified.
11. One for each kind of receptacle with AFCI and GFCI devices and cover plate accessory specified, in each finish and color specified.
12. One for each kind of locking receptacle and cover plate accessory specified, in each finish and color specified.
13. One for each kind of pin-and-sleeve receptacle specified, in each finish and color specified.
14. One for each kind of cord connector specified, in each finish and color specified.

D. Field Quality-Control Submittals:

1. Field quality-control reports.

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1.8 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:
 - 1. Dimmers.
 - 2. Fan-speed controllers.
 - 3. Single straight-blade receptacles.
 - 4. Duplex straight-blade receptacles.
 - 5. Duplex straight-blade receptacles with integral switching means.
 - 6. Receptacles with AFCI and GFCI devices.
 - 7. Locking receptacles.
 - 8. Pin-and-sleeve receptacles.
 - 9. Spring-driven commercial/industrial-use cord reels.
- B. Sample warranties.

1.9 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Items: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Extra Keys for Key Lock Switches: One of each kind.
 - 2. SPD Receptacles: Equal to 10 percent of quantity installed for each kind specified, but no fewer than two units.
 - 3. Controlled Receptacles: Equal to 10 percent of quantity installed for each kind specified, but no fewer than two units.
 - 4. Cord Connectors: One of each kind.
- B. Special Tools:
 - 1. Proprietary equipment and software required to maintain, repair, adjust, or implement future changes to controlled receptacles.
 - 2. Proprietary equipment required to maintain, repair, adjust, or implement future changes to cord connectors.

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1.10 WARRANTY FOR DEVICES

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.
 - 1. Extended Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: Eight years from date of Substantial Completion; full coverage for materials that failed because of transient voltage surges only, free on board origin and destination, freight prepaid.

1.11 WARRANTY FOR CORD REELS

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to repair or replace assemblies that fail to perform as specified within extended warranty period.
 - 1. Extended Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that components of cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.
 - 1. Extended Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
 - 2. Follow-On Extended Warranty Period: Eight years from date of Substantial Completion; full coverage for materials that failed because of transient voltage surges only, free on board origin and destination, freight prepaid.

PART 2 - PRODUCTS

2.1 GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

- A. Toggle Switch:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

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2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN WMUZ and UL 20.
 4. Options:
 - a. Device Color: White in accordance with NEMA WD 1 or as indicated on Architectural Drawings.
 - b. Configuration:
 - 1) General-duty, 120-277 V, 15 A, single pole, double pole, three way, four way.
 - 2) General-duty, 120-277 V, 20 A, single pole, double pole, three way, four way.
 - 3) Extra-heavy-duty, 120-277 V, 15 A, single pole, double pole, three way, four way.
 - 4) Extra-heavy-duty, 120-277 V, 20 A, single pole, double pole, three way, four way.
 - 5) Extra-heavy-duty, 120-277 V, 30 A, single pole, double pole, three way, four way.
 - 6) Retain "Accessories" Subparagraph below only if this cover plate must exactly match color of this wiring device. Use Section 260533 "Raceway and Boxes for Electrical Systems" to specify common covers or cover plates with matching colors or finishes for use with multiple wiring devices.
 5. Accessories:
 - a. Cover Plate: 0.060 inch 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.
- B. Toggle Switch with Forked Key Lock:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN WMUZ and UL 20.

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4. Options:
 - a. Device Color: White or as indicated on architectural Drawings.
 - b. Configuration:
 - 1) 120-277 V, 15 A, single pole, double pole, three way, four way.
 - 2) 120-277 V, 20 A, single pole, double pole, three way, four way.
 - 3) 120-277 V, 30 A, single pole, double pole.
- C. Type I Dimmer Switch:
1. Unless otherwise noted on plans Dimmer switches will be part of Section 26 0923 “Digital Occupancy and Daylight Management Control System”. If called out separately the information below will be followed for Dimmer switches.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. GE Lighting; General Electric Company.
 - c. Leviton Manufacturing Co., Inc.
 - d. Lutron Electronics Co., Inc.
 - e. Pass & Seymour; Legrand North America, LLC.
 - f. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 3. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 4. General Characteristics:
 - a. Reference Standards: UL CCN EOYX and UL 1472 Type I dimmer.
 5. Options:
 - a. Device Color: White or as indicated on architectural Drawings.
 - b. Switch Style: Toggle, Push button.
 - c. Dimming Control Style: Slide.
 6. Accessories:
 - a. Cover Plate: 0.060 inch 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.
- D. Air-Gap Fan-Speed Controller Switch:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:

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- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN GQHG and UL 1917.
4. Options:
 - a. Device Color: White or as indicated on architectural Drawings.
5. Accessories:
 - a. Cover Plate: 0.060 inch 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.

2.2 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

A. Single Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color: White or as indicated on architectural Drawings].
 - b. Configuration:
 - 1) General-duty, NEMA 5-15R, NEMA 5-20R, NEMA 5-30R, NEMA 5-50R.
 - 2) General-duty, smooth face, NEMA 5-15R, NEMA 5-20R.
 - 3) General-duty, NEMA 6-15R, NEMA 6-20R, NEMA 6-30R, NEMA 6-50R.
 - 4) General-duty, smooth face, NEMA 6-20R.
 - 5) General-duty, NEMA 14-30R (Dryer), NEMA 14-50R (Range).
 - 6) Heavy-duty, NEMA 5-30R, NEMA 5-50R.
 - 7) Heavy-duty, NEMA 6-30R, NEMA 6-50R.
 - 8) Heavy-duty, NEMA 7-20R, NEMA 7-30R, NEMA 7-50R.
 - 9) Heavy-duty, NEMA 14-20R, NEMA 14-30R (Dryer), NEMA 14-50R (Range), NEMA 14-60R.
 - 10) Heavy-duty, NEMA 15-20R, NEMA 15-30R, NEMA 15-50R, NEMA 15-60R.

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- 11) Heavy-duty, NEMA 18-20R, NEMA 18-30R, NEMA 18-50R, NEMA 18-60R
 - 12) Extra-heavy-duty, NEMA 5-15R, NEMA 5-20R.
 - 13) Extra-heavy-duty, NEMA 6-15R, NEMA 6-20R.
5. Accessories:
- a. Cover Plate: 0.060 inch 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.
- B. Tamper-Resistant, Clock Hanger Straight-Blade Receptacle:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pass & Seymour; Legrand North America, LLC.
 - b. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 4. Options:
 - a. Finish: White nylon.
 - b. Configuration: Recessed, smooth wallplate; NEMA 5-15R, NEMA 5-20R.
- C. Tamper-Resistant, Floor-Mounted Display Straight-Blade Receptacle:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pass & Seymour; Legrand North America, LLC.
 - b. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 - b. Configuration: NEMA 5-15R.
 4. Options:
 - a. Finish: Nickel plated.

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- D. spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

2.3 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color: White in accordance with NEMA WD 1, or as indicated on Architectural Drawings.
 - b. Configuration:
 - 1) General-duty, NEMA 5-20R.
 - 2) General-duty, smooth face, NEMA 5-20R.
 - 3) General-duty NEMA 6-20R.
 - 4) General-duty, smooth face, NEMA 6-20R.
 - 5) Heavy-duty, NEMA 5-20R.
 - 6) Heavy-duty, smooth face, NEMA 5-20R.
 - 7) Heavy-duty, NEMA 6-20R.
5. Accessories:
 - a. Cover Plate: 0.060 inch 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.

B. Tamper-Resistant Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:

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- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 4. Options:
 - a. Device Color: White in accordance with NEMA WD 1 or as indicated on Drawings.
 - b. Configuration:
 - 1) General-duty, NEMA 5-20R.
 - 2) General-duty, smooth face, NEMA 5-20R.
 - 3) Heavy-duty, NEMA 5-20R.
 - 4) Heavy-duty, smooth face, NEMA 5-20R.
 - 5) Extra-heavy-duty, NEMA 5-20R.
 5. Accessories:
 - a. Cover Plate: 0.060 inch 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.
- C. Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration:
 - 1) General-duty, NEMA 5-20R; two USB-A ports.
 - 2) General-duty, NEMA 5-20R; two USB-C ports.
 - 3) General-duty, NEMA 5-20R; one USB-A port; one USB-C port.
 - 4) General-duty, smooth face, two USB-A ports.
 - 5) General-duty, smooth face, four USB-A ports.
 5. Accessories:

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- a. Cover Plate: 0.060 inch 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.

D. Wired Full-Controlled Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated, Lighting.
 - b. Pass & Seymour; Legrand North America, LLC.
 - c. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTX1 and UL Subject 498B.
4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration: NEMA 5-20R.
5. Accessories:
 - a. Cover Plate: 0.060 inch 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.

E. Wired Half-Controlled Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated, Lighting.
 - b. Pass & Seymour; Legrand North America, LLC.
 - c. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTX1 and UL Subject 498B.
4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration: NEMA 5-20R.
5. Accessories:

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- a. Cover Plate: 0.060 inch 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.

2.4 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

A. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI Device:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
- 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 3. General Characteristics:
 - a. Reference Standards: UL CCN AWBZ, UL 498, UL 1699, and UL Subject 1699A.
- 4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
- 5. Accessories:
 - a. Cover Plate: 0.060 inch 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.

B. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with AFCI and GFCI Device:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
- 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 3. General Characteristics:

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- a. Reference Standards: UL CCN KCXX, UL 498, UL 943, UL 1699, and UL Subject 1699A.
 4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
 5. Accessories:
 - a. Cover Plate: 0.060 inch 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.
- C. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
 4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
 5. Accessories:
 - a. Cover Plate: 0.060 inch 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.
- D. General-Grade, Weather-Resistant, Tamper-Resistant, Nightlight-Type, Lighted Duplex Straight-Blade Receptacle with GFCI Device:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:

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- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
4. Options:
 - a. Device Color: White or as indicated on Architectural Drawings.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
5. Accessories:
 - a. Cover Plate: 0.060 inch 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.

2.5 LOCKING RECEPTACLES

- A. NEMA, 125 V, Locking Receptacle: Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color: Black with yellow voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, NEMA L5-20R, NEMA L5-30R.
- B. NEMA, 250 V, Locking Receptacle:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour; Legrand North America, LLC.
 - d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

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3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color: Black with blue voltage indication on face.
 - b. Configuration:
 - 1) 2 pole, 3 wire, grounding, NEMA L6-20R, NEMA L6-30R.
 - 2) 3 pole, 4 wire, grounding, NEMA L15-20R, NEMA L15-30R.
 - 3) 4 pole, 4 wire, non-grounding, NEMA L18-20R, NEMA L18-30R.
 - 4) 4 pole, 5 wire, grounding, NEMA L21-20R, NEMA L21-30R.

2.6 PIN-AND-SLEEVE RECEPTACLES

A. C2 Series, 125/250 V, Pin-and-Sleeve Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.
 - b. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - c. Crouse-Hinds; Eaton, Electrical Sector.
 - d. Killark; Hubbell Incorporated, Construction and Energy.
 - e. Leviton Manufacturing Co., Inc.
 - f. Pass & Seymour; Legrand North America, LLC.
 - g. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN QLIW, UL 1682, and UL 1686.
 - b. Series: UL 1686 C2 and IEC 60309-2 Series II.
 - c. Voltage Rating: 125/250 V.
4. Options:
 - a. Configuration:
 - 1) 2 pole, 3 wire, 20 A, 30 A, IP67, 30 A, IP69k, 60 A, IP67, 60 A, IP69k, 100 A.
 - 2) 3 pole, 4 wire, 20 A, 30 A, IP67, 30 A, IP69k, 60 A, IP67, 60 A, IP69k, 100 A, IP67, 100 A, IP69k.
 - 3) 4 pole, 5 wire, 20 A, 30 A, IP67, 30 A, IP69k, 60 A, IP67, 60 A, IP69k, 100 A, IP67, 100 A, IP69k.

B. C2 Series, 480 V, Pin-and-Sleeve Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Products Division.

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- b. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - c. Crouse-Hinds; Eaton, Electrical Sector.
 - d. Killark; Hubbell Incorporated, Construction and Energy.
 - e. Leviton Manufacturing Co., Inc.
 - f. Pass & Seymour; Legrand North America, LLC.
 - g. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Regulatory Requirements:
- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
- a. Reference Standards: UL CCN QLIW, UL 1682, and UL 1686.
 - b. Series: UL 1686 C2 and IEC 60309-2 Series II.
 - c. Voltage Rating: 480 V.
4. Options:
- a. Configuration:
 - 1) 2 pole, 3 wire, 20 A, 30 A, IP67, 30 A, IP69k, 60 A, IP67, 60 A, IP69k, 100 A.
 - 2) 3 pole, 4 wire, 20 A, 30 A, IP67, 30 A, IP69k, 60 A, IP67, 60 A, IP69k, 100 A, IP67, 100 A, IP69k.
 - 3) 4 pole, 5 wire, 20 A, 30 A, IP67, 30 A, IP69k, 60 A, IP67, 60 A, IP69k, 100 A, IP67, 100 A, IP69k.

2.7 CONNECTORS, CORDS, AND PLUGS

A. Outdoor-Use, Watertight, Sealed Cord Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
- a. Ericson Manufacturing Company.
2. Regulatory Requirements:
- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
- a. Reference Standards: UL CCN AXUT and UL 498.
4. Options:
- a. Configuration:
 - 1) NEMA 6-20.
 - 2) NEMA L5-20 with diagnostic LED indicator.
 - 3) NEMA L5-30.

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- 4) NEMA L6-20.
- 5) NEMA L6-30.
- 6) NEMA L7-20.
- 7) NEMA L7-30.
- 8) NEMA L14-20.
- 9) NEMA L14-30.
- 10) NEMA L15-20.
- 11) NEMA L15-30.
- 12) NEMA L16-20.
- 13) NEMA L16-30.
- 14) NEMA L17-30.
- 15) NEMA L18-30.

2.8 FINISHES

A. Device Color:

Finishes: Manufacturer offers a minimum of 6 finish and trim combinations, including painted and satin anodized aluminum finishes and wood grain type trim. Furnish with final finish as selected from samples.

1. Wiring Devices Connected to Normal Power System: White or as indicated on Architectural Drawings unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.

B. Wall Plate Color: For plastic covers, match device color.

2.9 MANUAL SWITCHES AND PLATES

- A. Locator Light: Internal illumination helps locate switch in the dark. Use where indicated.
- B. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

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3.2 INSTALLATION OF SWITCHES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 - 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 3. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 - 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.3 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 - 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 - a. Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
 - 4. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 - 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black filled lettering, and provide durable wire markers or tags inside device box or outlet box.
- D. Interfaces with Other Work:

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1. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.
2. Coordinate installation of new products for with existing conditions.

3.4 INSTALLATION OF LOCKING RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 4. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
- D. Interfaces with Other Work:
 1. Coordinate with all other trades in this project and systems.

3.5 INSTALLATION OF PIN-AND-SLEEVE RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in UL 1686.
 4. Consult Architect for resolution of conflicting requirements.

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C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

D. Interfaces with Other Work:

1. Coordinate with all other trades in this project and systems

3.6 INSTALLATION OF CORD REELS AND FITTINGS

- A. Comply with manufacturer's instructions.

3.7 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS

- A. Comply with manufacturer's instructions.

3.8 FIELD QUALITY CONTROL OF SWITCHES

- A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' instructions.
2. See Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
3. Check TVSS receptacle indicating lights for normal indication
4. Test ground-fault circuit interrupter operation with both local and remote fault simulations according to manufacturer recommendations.
5. Unit will be considered defective if it does not pass tests and inspections.
6. Remove and replace defective units and retest.

- C. Assemble and submit test and inspection reports.

D. Manufacturer Services:

1. Engage factory-authorized service representative to supervise field tests and inspections.

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3.9 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections
 - 1. Insert and remove test plug to verify that device is securely mounted.
 - 2. Verify polarity of hot and neutral pins.
 - 3. Measure line voltage.
 - 4. Measure percent voltage drop.
 - 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 - 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
 - 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
- C. Nonconforming Work:
 - 1. Device will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- D. Assemble and submit test and inspection reports.
- E. Manufacturer Services:
 - 1. Engage factory-authorized service representative to supervise field tests and inspections.

3.10 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections:
 - 1. Insert and remove test plug to verify that device is securely mounted.
 - 2. Verify polarity of hot and neutral pins.
 - 3. Measure line voltage.
 - 4. Measure percent voltage drop.

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5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
- C. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- D. Assemble and submit test and inspection reports.
- E. Manufacturer Services:
1. Engage factory-authorized service representative to supervise field tests and inspections.

3.11 FIELD QUALITY CONTROL OF PIN-AND-SLEEVE RECEPTACLES

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections:
1. Insert and remove test plug to verify that device is securely mounted.
 2. Measure line voltage.
 3. Measure percent voltage drop.
 4. Measure ground impedance, which must be not greater than 2 ohms.
 5. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
- C. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- D. Assemble and submit test and inspection reports.
- E. Manufacturer Services:
1. Engage factory-authorized service representative to supervise field tests and inspections.

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3.12 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections:
 - 1. Perform tests and inspections indicated in manufacturer's instructions.
- C. Nonconforming Work:
 - 1. Components and assemblies will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- D. Assemble and submit test and inspection reports.
- E. Manufacturer Services:
 - 1. Engage factory-authorized service representative to support field tests and inspections.

3.13 FIELD QUALITY CONTROL OF CONNECTORS, CORDS, AND PLUGS

- A. Field tests and inspections must be witnessed by Architect.
- B. Tests and Inspections:
 - 1. Perform tests and inspections indicated in manufacturer's instructions.
- C. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- D. Assemble and submit test and inspection reports.
- E. Manufacturer Services:
 - 1. Engage factory-authorized service representative to supervise field tests and inspections.

3.14 SYSTEM STARTUP FOR SWITCHES

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks for momentary switches, dimmer switches, and fan-speed controller switches in accordance with manufacturer's instructions.

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3.15 ADJUSTING

- A. Occupancy Adjustments for Controlled Receptacles: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- B. Cord Reels and Fittings: Adjust spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

3.16 PROTECTION

- A. Devices:
 - 1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
 - 2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- B. Cord Reels and Fittings:
 - 1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- C. Connectors, Cords, and Plugs:
 - 1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.17 CLEANING

- A. General: Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices. Replace wall plates or devices marked with pencil, pen, or other non-standard marking system. Thoroughly clean all device plates, remove fingerprints, smudges, and dirt.

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B. Dimmer Switches:

1. Wattage rating exceeds connected load by 30 percent minimum, except as otherwise indicated.

END OF SECTION

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Receptacle switches.
 - 4. Shunt trip switches.
 - 5. Molded-case circuit breakers (MCCBs).
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 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.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.

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3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.
- 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in [PDF] [and] <Insert calculation program format> electronic format.

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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: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Fuse Pullers: Two for each size and type.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 - 2. Altitude: Not exceeding 6600 feet.

1.10 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: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

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2.2 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.

2.3 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB (Electrification Products Division).
 - 2. Eaton.
 - 3. Schneider Electric USA (Square D).
 - 4. Siemens Industry, Inc., Energy Management Division.
- B. Type HD, Heavy Duty:
 - 1. Single, Double, throw.
 - 2. Three, six pole.
 - 3. 250, 600-V ac.
 - 4. 1200 A and smaller , 200 A and smaller.
 - 5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified and or indicated fuses.
 - 6. 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.

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3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: [One] [Two] NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac, 120-V.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB (Electrification Products Division).
 2. Eaton.
 3. Schneider Electric USA (Square D).
 4. Siemens Industry, Inc., Energy Management Division.
- 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, 250, 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. Type HD, Heavy Duty, Six Pole, Single Throw, 250, 600-V ac, 200 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.
- D. Type HD, Heavy Duty, Three Pole, Double Throw, 250, 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.
- E. 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.

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3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. See "Control Power Options" Article in the Evaluations for various sources available for control power. Although other voltages are available, the Section Text includes only those that are most frequently encountered and listed in manufacturers' literature. Integrally mounted control power is not available in safety switches.
6. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac, 120-V ac.
7. Hookstick Handle: Allows use of a hookstick to operate the handle.
8. Lugs: Compression type, suitable for number, size, and conductor material.
9. Service-Rated Switches: Labeled for use as service equipment.

2.5 RECEPTACLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB, Electrification Products Division.
 2. Eaton.
 3. Siemens Industry, Inc., Energy Management Division.
 4. Square D; Schneider Electric USA.
- B. Listed manufacturers offer similar but different options for voltage and ampere ratings and the make and model of receptacles available for factory installation on their switches. See the "Receptacle Switches" Article in the Evaluations. Not all listed voltage and ampere ratings and enclosure types listed in "Enclosures" Article are available from all listed manufacturers.
- C. Show pole quantities and voltage and ampere ratings of switches on Drawings. Retain one of last two options in first paragraph below depending on whether fuse applications and class designations are indicated on Drawings or specified in Section 262813 "Fuses." Show fuse ampere ratings on Drawings.
- D. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 250, 600-V ac, 30, 60, 100A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified and or indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- E. Type HD, Heavy-Duty, Three Pole, Single-Throw Non-fusible Switch: 250, 600-V ac, 30, 60, 100A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

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- F. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
- G. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).
- H. 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.
 - 4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 5. See "Control Power Options" Article in the Evaluations for various sources available for control power. Although other voltages are available, the Section Text includes only those that are most frequently encountered and listed in manufacturers' literature. Integrally mounted control power is not available in safety switches.
 - 6. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac, 120-V ac.
 - 7. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 8. Lugs: Compression type, suitable for number, size, and conductor material.
 - 9. Service-Rated Switches: Labeled for use as service equipment.

2.6 SHUNT TRIP SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton (Bussmann & Edison).
 - 2. Littelfuse, Inc.
 - 3. Mersen USA.
- A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.
- B. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 250, 600-V ac, 30, 60, 100A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt

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pads to accommodate specified and or indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

- C. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 250, 600-V ac, 30, 60, 100A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Control Circuit: 120-V ac; obtained from [integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.
- E. Accessories:
 - 1. Oiltight key switch for key-to-test function.
 - 2. Oiltight green ON pilot light.
 - 3. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
 - 4. Form C alarm contacts that change state when switch is tripped.
 - 5. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac, 24-V dc, coil voltage.
 - 6. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
 - 7. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 8. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
 - 9. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 10. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac, 120-V ac.
 - 11. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 12. Lugs: Compression type, suitable for number, size, and conductor material.
 - 13. Service-Rated Switches: Labeled for use as service equipment.

2.7 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB (Electrification Products Division).
 - 2. Eaton.

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3. NOARK Electric North America.
 4. Schneider Electric USA (Square D).
 5. Siemens Industry, Inc., Energy Management Division.
 6. General Switch Corporation
- B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
- D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated or series rated as indicated on the Drawings. Circuit breaker/circuit breaker or Fuse/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement.
- E. MCCBs shall be equipped with a device for locking in the isolated position.
- F. Lugs shall be suitable for 167 deg F rated wire on 125-A circuit breakers and below, sized according to the 167 deg F temperature rating in NFPA 70.
- G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
1. Instantaneous trip.
 2. Long- and short-time pickup levels.
 3. Long- and short-time time adjustments.
 4. Ground-fault pickup level, time delay, and I-squared t response.

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- K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- O. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system.
 - 6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 9. Alarm Switch: One NO and NC contact that operates only when circuit breaker has tripped.
 - 10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - 11. Zone-Selective Interlocking: Integral with electronic and ground-fault trip unit; for interlocking ground-fault protection function.
 - 12. Electrical Operator: Provide remote control for on, off, and reset operations.

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13. Accessory Control Power Voltage: [Integrally mounted, self-powered] [Remote mounted and powered]; [24-V ac] [120-V ac] [208-V ac] [240-V ac] [12-V dc] [24-V dc] [120-V dc Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac, 120-V ac.

2.8 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB (Electrification Products Division).
 2. Eaton.
 3. NOARK Electric North America.
 4. Schneider Electric USA (Square D).
 5. Siemens Industry, Inc., Energy Management Division.
 6. Westinghouse Electric Corp.; Distribution & Control Business Unit
- B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- D. Features and Accessories:
 1. Standard frame sizes and number of poles.
 2. Lugs:
 - a. Compression type, suitable for number, size, trip ratings, and conductor material.
 - b. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below 167 deg F rated wire, sized according to the 167 deg F temperature rating in NFPA 70.
 3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 5. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

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6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO and NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered and powered; 24-V ac, 120-V ac.

2.9 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.
 1. Enclosed, Molded-Case Circuit Breaker: with lockable handle.
 2. Application Listing: Appropriate for application, including heating, air-conditioning, and refrigerating equipment.
 3. Circuit Breakers, 200 A and Larger: Trip units interchangeable within frame size.
 4. Circuit Breakers, 400 A and Larger: Field-adjustable, short-time and continuous current settings.
 5. Indoor, Dry and Clean Locations: NEMA 250, [Type 1] <Insert type>.
 6. Outdoor Locations: NEMA 250, [Type 3R] <Insert type>.
 7. [Kitchen] [Wash-Down] Areas: NEMA 250, [Type 4X] <Insert type>, [stainless steel] <Insert material>.
 8. Other Wet or Damp, Indoor Locations: NEMA 250, [Type 4] <Insert type>.
 9. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 1. Hazardous Areas Indicated on Drawings: NEMA 250, [Type 7] [Type 9] <Insert type>
Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. Kitchen, Wash-Down Areas: NEMA 250, Type 4X.
 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

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5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.
- B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1), gray baked enamel paint, electrodeposited on cleaned, phosphatized galvanized steel (NEMA 250 Types 3R, 12), a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel), copper-free cast aluminum alloy (NEMA 250 Types 7, 9).
 - C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
 - D. Operating Mechanism: The circuit-breaker operating handle shall be [externally operable with the operating mechanism being an integral part of the box, not the cover] [directly operable through the front cover of the enclosure (NEMA 250 Type 1)] [directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R)] [externally operable with the operating mechanism being an integral part of the cover (NEMA 250 Types 7, 9)]. 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.
 - E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
 - F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

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3.2 PREPARATION

- 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 Architect, 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 Architect's, Owner's written permission.
 4. Comply with NFPA 70E.

3.3 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. Kitchen, Wash-Down Areas: NEMA 250, Type 4X.
 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.4 INSTALLATION

- A. Install disconnect switches and circuit breakers in locations as indicated, according to manufacturer's written instructions.
- B. Install disconnect switches and circuit breakers level and plumb.
- C. Install wiring between disconnect switches, circuit breakers, control, and indication devices.
- D. Connect disconnect switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer.
1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

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- E. 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.
- F. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- G. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- H. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- I. Install fuses in fusible devices.
- J. Comply with NFPA 70 and NECA 1.

3.5 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.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[with the assistance of a factory-authorized service representative].
- E. 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:

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- 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."

F. 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.

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- 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;

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- 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. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- G. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- H. 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.

Consider the following:

3.7 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.

3.8 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

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- B. Set field-adjustable circuit-breaker trip ranges[as specified in Section 260573.16 "Coordination Studies."] [to values indicated on the Drawings.] [to values indicated in attached schedule.]

END OF SECTION

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SECTION 23 0500 – COMMON WORK REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. See General Conditions and Supplemental General Conditions.
- B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this Section and all subsequent sections of this Division and form a part of the contract.
- C. See Division 25 for Facilities Management System.

1.2 DESIGN INTENT

- A. The project intent is to replace the HVAC systems within the Reidlinger and Allied Health buildings which are joined with a common lobby between. The intent is to eliminate gas burning HVAC equipment within these two buildings as part of this project. The new equipment includes packaged variable air volume units and constant volume roof top units. This equipment includes heat pump type equipment and/or electric heating components.
- B. The project is a multiphase project with intentions to replace hvac equipment in manor that minimizes the operation of the buildings.

1.3 INDEX OF SPEC SECTIONS FOR THIS DIVISION

23 0500	Common Work Requirements for HVAC
23 0501	Demolition
23 0548	Vibration and Seismic Controls for HVAC
23 0549	HVAC and Electrical Installation Coordination
23 0593	Testing, Adjusting and Balancing of Mechanical Systems
23 0700	Mechanical Systems Insulation
23 2313	Refrigerant Piping System and Equipment
23 3000	Air Tempering System and Equipment
23 7413	Packaged Outdoor Central Station Air Handling Units

1.4 DEFINITIONS

- A. General: Terms will have meanings as defined in Webster's Eleventh New Collegiate Dictionary except as noted below.
- B. Entities
 - 1. Owner: New Mexico State University
 - 2. Engineer: Bridgers & Paxton
 - 3. Owner's Agents: The Engineer, and others authorized to act on behalf of the Owner.

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C. Actions

1. Supply: Procure and deliver to the site with all features as specified, required per code, and as required for proper installation. Include submittals, O&M manuals, operator instructions, and warranty.
2. Install: Set in place in accordance with manufacturer's instructions, contract documents, and applicable codes and standards. Coordinate the installation with other disciplines, start, and demonstrate proper operation.
3. Furnish: Supply and install.
4. Provide: Supply and install.
5. Accepted: By the Owner's Representative except as noted.
6. Approved: By the Owner's Representative except as noted.
7. Review: By the Engineer except as noted.

D. Locations

1. Buried: Surrounded by soil or other material, either beneath the building or exterior to the building.
2. Exterior: Exposed to rain or snow. Examples include rooftop locations, spaces around cooling towers, pipe racks, etc.
3. Interior: Not exterior or buried. Examples include not only spaces within the heated envelope of the building, but also unheated attics, covered loading docks in which spaces are protected from rain and snow, utility tunnels, sheds, etc.
4. Finished Spaces: Interior spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated attics, spaces above ceilings, crawlspaces, and tunnels.
5. Exposed: Exposed to view. Examples include finished spaces mechanical equipment rooms, rooftops, etc.
6. Concealed: Not Exposed.

E. Other Definitions:

1. 24/7: 24 Hr/day, 7 days per week, year-round.
2. AHJ: Authorities having jurisdiction. The authorities having jurisdiction over this project are established by statute, and include governmentally designated building departments, the fire marshal, fire departments, etc. No attempt is made to list all such entities here; a qualified Contractor is expected to know and coordinate with the various authorities having jurisdiction.
3. FMS: Facility Management System
4. Local: Based no further from the job site than the Engineer is. For example, where the specifications call for a local factory authorized service agent, then on a daily basis that agent must be based in an office or warehouse located no further from the project site than the Engineer's office.
5. OAE: Or approved equal.

1.5 CODES AND PERMITS

- A. Perform all work in accordance with the 2021 International Building Code, 2018 International Energy Conservation Code, the 2021 Uniform Plumbing Code, and the 2021 Uniform Mechanical Code, as adopted and interpreted by the State of New Mexico and City of Alamogordo and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements,

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the drawings and/or specifications shall govern. Contractor shall hold and save the Owner and his agents free and harmless from liability of any nature or kind arising from the Contractor's failure to comply with codes and ordinances.

- B. Secure and pay for all permits necessary for performance of the work, including utility connections, extensions, meter pits and meter sets and tap fees for water, storm sewer, sanitary sewer and natural gas, unless otherwise specified herein.
- C. Comply with the requirements of, and the recommendations of:
 - 1. Applicable county and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances
 - 2. National Electrical Manufacturer's Association
 - 3. National Electrical Code
 - 4. Underwriters Laboratories
 - 5. American National Standards Institute
 - 6. American Society for Testing Materials
 - 7. Local utility companies
 - 8. National Fire Protection Association
 - 9. ASME Boiler and Pressure Vessel Codes
 - 10. Occupational Safety and Health Administration
 - 11. International Fire Code
 - 12. Midwest Insulation Contractors' Association (MICA)
 - 13. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - 14. American Society of Sanitary Engineering
 - 15. American Gas Association

1.6 PRIOR APPROVAL

- A. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division. For the items listed below, the specified manufacturers and providers are the only ones presently approved, and may be the only ones allowed:
 - 1. Air Handling Units and Air Conditioning Units
 - 2. Facility Management System

1.7 DOCUMENT MANAGEMENT

- A. Contractor is encouraged to use a web-based document management system for RFIs and submittals. If used, Contractor shall provide and pay for licenses and training for the engineer's project personnel. The section below describes procedures for handling submittals if a web-based document management system is not used. If a web-based system is used, the procedures below shall be modified as appropriate.

1.8 SUBMITTALS.

- A. Prior to purchasing materials, equipment and services, submit descriptive literature for review.
- B. See individual specification sections within this division for additional submission requirements. The following describes general submittal procedures. More specific procedures will be

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established after award. Whenever electronic files are to be submitted, e-mail them through normal channels. But if files are too large to e-mail, then submit them in quantities as described below.

1. Submittal Schedule: Along with the first item submitted for review, include a schedule listing all items to be submitted and an approximate date for each submittal. Submit this schedule in both hard copy and electronic form (Microsoft Excel). Normal review time will be 10 working days. Schedule should identify any submittals for which expedited review is requested. Update this schedule and resubmit it monthly (by e-mail) for information.
 2. Include the following information with each submittal:
 - a. Cover sheet identifying the project name, contractor, engineer, and items included. Indicate symbol numbers, spec section, etc.
 - b. A blank space large enough to accept a review stamp.
 - c. Performance under the specified conditions
 - d. Cover sheet shall clearly identify and HIGHLIGHT any ways in which the submitted materials, equipment or services deviate from the Specifications.
 3. Quantities:
 - a. Submit electronically as a searchable PDF document. Include electronic bookmarks for submittals that contain multiple items for review.
 4. Engineer will review one original submittal and one resubmittal for each item. If the Contractor fails to provide the required data or acceptable items with his second submittal, he will be charged for the Engineer's costs for the third and subsequent reviews.
 5. Required Information: Submit information to allow the Engineer to easily determine whether the submitted components comply with the general design intent. Include relevant descriptions of materials, features, performance, quality and dimensions. Cross out all features, options and accessories which will not be provided. It is assumed that all specified, indicated and/or required features will be provided unless specifically noted otherwise.
 6. Where specifications require a local factory authorized service agent, submit the name, address, and contact information for this agent. Include this information also in the O&M Manual.
- C. Review of Submittals: Engineer will review submittals for general conformance with the design intent.
1. Review of a separate item as such will not indicate review of the assembly in which the item functions.
 2. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work.
 3. Review will not relieve the Contractor of responsibility to comply with the contract requirements, or responsibility to ensure that equipment fits within the allotted space with required clearances for equipment operation, service and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC).
 4. For commodity type items (plumbing fixtures, terminal units, registers, diffusers, etc), Engineer will review submittals for type only. Contractor to coordinate sizes and quantities.

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5. Actions: Engineer will return submittals with one of the following actions:

NO EXCEPTIONS TAKEN	Contractor may proceed with the work as submitted
EXCEPTIONS AS NOTED	Contractor may proceed with the work and without resubmittal provided he complies with all exceptions noted in the submittal, and so states in a letter
REVISE AND RESUBMIT	Resubmit in accordance with the indicated comments
REJECTED	Resubmit in accordance with the contract documents
RETURNED WITHOUT ACTION	This submittal has not been reviewed, and therefore the Engineer is returning it with no direction to the Contractor.

D. Substitutions:

1. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or if any work is installed in a manner which is not in conformance with the requirements of this specification and for which the Contractor has not received written authorization, remove such unauthorized work and install work in accordance with the contract documents at no change in contract amount.
2. Authorized Substitutions: Provide all accessories and features as required and coordinate substitutions with other disciplines. Bear any extra expenses resulting from the use of substitutions which affect adjoining or related work required in this division or other divisions of the work.
3. If the Contractor substitutes equipment for that indicated on the drawings, he shall prepare a 1/4 inch = 1foot installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will properly fit within the space with adequate clearance for maintenance and replacement. Submit this drawing for review.

E. Schedule: Submit all submittals in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time. Be aware that there is risk in ordering components, fabricating work, and/or installing work prior to review. If the Contractor proceeds prior to review, and then the review comments required modifications to work which has begun or has been completed, then Contractor must comply with the review comments at no change in contract amount or schedule.

F. Submittals Required under this Specification Section:

1. Electrical Components: Motors, Motor Controllers, and Variable Speed Drives
2. Identification: Products used to identify equipment, ductwork, valves, piping, and control devices.
3. General Construction Components: Roof Curbs & Access doors.

1.9 MISCELLANEOUS PROVISIONS

A. Qualifications

1. All mechanics shall be skilled in their respective trade.
2. All welders shall be certified in accordance with the ASME Boiler Test Code, Section IX, latest issue.

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- B. Regulated Materials: Comply with all state, local and federal regulations regarding the storage, handling or disposal of oils, lubricants, cleaning agents, refrigerants, other liquids and gases, and hazardous materials.
- C. Factory Identification: Provide all materials and equipment with labels sufficient to show compliance with these specifications and the performance requirements indicated on the drawings. All equipment shall carry a permanent label installed by the manufacturer stating that the equipment complies with ASHRAE/IESNA Std. 90.1.
- D. Hazardous Conditions: Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.
- E. Hazard Signs
 - 1. Provide a sign reading, "Hazardous Area - Authorized Personnel Only" on the doors to all equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments.
 - 2. Provide a sign reading, "Confined Space - Entry by authorized personnel only by permit" for all confined spaces. Confined spaces shall be as designated by OSHA Standard 1910.146. This generally means a space that:
 - a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
 - b. Has limited or restricted means for entry or exit (for example, tanks, vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
 - c. Is not designed for continuous employee occupancy.
 - 3. Survey the final premises to determine where any potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.10 **GUARANTEE-WARRANTY**

- A. Warranties shall run for one year from substantial completion unless indicated otherwise.
- B. The following warranty shall be binding:

"The Contractor warrants that this installation is free from mechanical defects. Contractor agrees to replace or repair any part of the installation which may fail within a period of one year after the date established below, provided that such failure is due to defects in materials or workmanship, or to failure to follow the specifications and drawings. This warranty shall begin on the date set forth in the Certificate of Substantial Completion, AIA Form G704, or other such date as documented in writing by the Owner's Representative."
- C. The extent of guarantees or warranties by equipment and/or materials manufacturers will not diminish the requirements of the Contractor's warranty to the Owner.

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PART 2 - PRODUCTS

2.1 PRODUCT GENERAL REQUIREMENTS

- A. General: Products supplied under Division 23 shall comply with the following except as noted elsewhere.
- B. Products shall be new; shall be the product of manufacturers regularly engaged in the production of plumbing, heating, ventilating, air conditioning, and control system equipment; and shall be the manufacturer's latest design. Specs and equipment schedules establish expectations regarding standard of quality and operating intent.
- C. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.
- D. Products shall be suitable for the conditions under which they are installed and operated. Prior to or during the submittal phase advise the Owner's representative and the Engineer in writing regarding any concerns about the suitability of the specified products for the intended application or service. Request clarification if any question exists regarding the design intent.
- E. Performance Ratings: Unless otherwise noted, all scheduled equipment performance is based on an elevation of 4300 feet above sea level. Adjust manufacturer's ratings accordingly.
- F. Structural Soundness: Products shall have structural integrity appropriate to the component and its application. Bases shall be rigid and shall keep all components in proper alignment. Structural integrity shall be adequate for both rigging and final installation. Components shall not be loose, rattle, or vibrate unnecessarily in their final installed condition.
- G. Corrosion Resistance: Equipment shall be of materials inherently corrosion resistant, or shall be finished with a corrosion-resistant finish suitable for the location in which the equipment is installed.
- H. Touch-up: If the factory finish of any component is damaged prior to substantial completion, touch up to original condition per manufacturer's recommendations.
- I. Equipment Access Doors or Panels: Provide access doors and panels within equipment to ensure good access to all components requiring inspection, service or maintenance. Provide appropriate hardware. Equipment installed outdoors shall be weather-tight.
- J. Fans: Statically and dynamically balanced, shaft first critical speed shall be above operating speed at design conditions.
- K. Bearings: Grease lubricated or permanently lubricated.
- L. V-Belt Drives: All components sized for 150% of motor HP, multiple belts shall be matched, fixed sheaves for motors 20 Hp and larger, adjustable sheaves for lower HP motors, all safety components for OSHA compliance (e.g., belt guard or other safety provisions) motor mounted on adjustable base. Provide a replacement sheave for each fixed sheave after T&B is complete. Include belt data in O&M manual. Gates Rubber Co, OAE.

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1. Belt Guards: Rigidly constructed and attached, removable, galvanized steel, expanded mesh. Design to provide ready access to bearings.
- M. Couplings: Provide coupling guard.
- N. Motors and VFDs: See requirements described elsewhere in this spec section.
- O. Drive Lines (starter or VFD, motor, coupling and shaft or v-belt drive and pulleys, and driven equipment): Coordinate with all suppliers and ensure all components are compatible to work as a system.
- P. Coils: ARI rated, copper tubes mechanically expanded into aluminum fins, galvanized steel casing, drainable, pressure tested to 150% of working pressure but not less than 300 psi.
- Q. Cooling Coil Drain Pans: Provide for all cooling coils, galvanized or stainless steel, double pitched with piped outlet. For units with more than one coil stacked, provide intermediate drain pans piped to the main drain pan.
- R. Filter Frames: Galvanized steel, provide wherever filters are specified.
- S. Roof Curbs and Support Rails for Roof-Mounted Equipment: Roof curbs should generally be supplied with the equipment which the curb supports, and shall comply with the requirements of the National Roofing Contractors' Association. Match curb to the requirements of the supported equipment. The roof pitch is indicated on the architectural drawings. If roof pitch exceeds the recommendations of the equipment manufacturer, provide a curb that will level the equipment. Factory fabricated, (see drawings for minimum height), structurally adequate for the load supported, not less than welded 18-gauge (16-gauge or heavier for sizes more than 50-inches) galvanized steel with minimum 1-inch fiberglass insulation, 2 x 2 wood nailer, and with cant and step if required to match specified roof. Provide damper tray for un-ducted fan applications. Ship small curbs fully assembled; large curbs may be knocked down for shipment.
- T. Electrical & Controls: Except where specifically noted, electric service to each component listed on the equipment schedules will be through a single electrical feed at the voltage indicated on the equipment schedules. Include all components, cabling and conduits to distribute power to all components which are factory supplied and mounted. Provide transformer(s) if required to serve unit-mounted components requiring electric service at voltages different from the main electric service, including controls components. Provide secondary overcurrent protection. Provide terminal strips for field-installed control wiring. Provide unit-mounted, unit-specific wiring diagrams on durable paper, attached to inside of control panel door or otherwise affixed to the unit. All electrical components shall be UL Listed or Recognized. All factory-installed electrical work shall comply with the NEC unless the overall unit is listed by an organization acceptable to the AHJ, and listed to a standard acceptable to the AHJ.
 1. Where equipment includes an LCD or other, similar display for operator interface, display all information in English. Displays should be readily understandable and should not require the user to look up display codes in a reference manual.
 2. Provide battery backup to retain all memory and programming, and to keep all clock-related functions powered through a 1-week power outage.
 3. Controls interface with the FMS:
 - a. Digital Inputs to FMS: 24V DC sourced from equipment.
 - b. Digital Outputs from FMS: Equipment to have form C relays, max 250V DC, 2 A.
 - c. Analog Inputs to FMS: 4-20 mA, 0-5V DC, or 0-10V DC sourced from equipment.

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- d. Analog Outputs from FMS: 4-20 mA sourced from FMS.

2.2 ELECTRICAL COMPONENTS

A. General: Except as noted, all electrical products and equipment shall comply with the requirements of this section, whether field installed or factory installed. See “Product General Requirements” and “Installation General Requirements” in Parts 2 & 3 of this spec section for additional requirements.

B. Motors

1. General: Except as noted motors shall be horizontal, open drip-proof, 4-pole, 1750 RPM, rated per NEMA MG-1, with fabricated steel or cast iron casing, motor terminal box adequately sized for conductors one-size larger than specified, SS nameplate per NEMA MG-1-20.60, connection diagram attached to motor, compression lugs for power feeds and ground conductor, grease lubricated sealed ball bearings or roller bearings with standard grease fitting zerk and relief tapping, factory lubricated, dynamically balanced to no more than 50% of the NEMA allowable vibration limits. For motors powering V-belt drives, provide a cast iron or steel base with slide rail and adjustable belt tension device. Install motors and equipment on foundations and align as required. 40 deg C rise and total temperature rise of 65 deg C ambient.
 - a. 3/4 hp and smaller: 115V, single phase, 60 Hz, split phase or permanent split capacitor (PSC), NEMA Type N or O, with built-in thermal overload protection.
 - 1) Multi-speed motors.
 - b. 1 hp and greater: 480 V, 3 phase, 60 Hz, squirrel cage induction type, NEMA design B, T-frame, with Class B or F insulation, lifting lugs, 150,000 hr L-10 bearings for direct-coupled applications, 50,000 hr L-10 bearings for belt-driven application with radial loads and pulley sizes per NEMA MG1-14.43. Service Factor: ODP motors shall be rated for 1.15 SF at 40oC or 1.0 SF at 65oC; TEFC motors shall be 1.0 SF.
 - 1) Two speed motors: Provide with two separate windings.
 - 2) Variable speed motors: Drive compatible per NEMA MG1-31, premium efficiency as specified below regardless of Hp, Class F insulation, minimum 5-year warranty.
2. Efficiency: Except as noted, motors shall be premium efficiency type, with nominal efficiencies not less than the following as per the Consortium on Energy Efficiency (CEE), and minimum power factor of 0.85:

HP	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	80.0	82.5	85.5	78.5
1.5	86.5	86.5	85.5	87.5	86.5	85.5
2	87.5	86.5	86.5	88.5	86.5	86.5
3	89.5	89.5	86.5	89.5	89.5	88.5
5	89.5	89.5	89.5	89.5	89.5	89.5
7.5	91.7	91.0	89.5	91.7	91.7	91.0
10	91.7	91.7	90.2	91.7	91.7	91.7
15	92.4	93.0	91.0	92.4	92.4	91.7
20	92.4	93.0	92.4	92.4	93.0	92.4
25	93.0	93.6	93.0	93.0	93.6	93.0
30	93.6	94.1	93.0	93.6	93.6	93.0

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3. Approved Manufacturers: General Electric Energy Saver, Baldor Super-E, Marathon Series E, Reliance Electric XE, Westinghouse TEE II, Eaton/Cutler Hammer, Toshiba, Louis Allis, or approved equal.
 4. If the Contractor proposes to furnish motors varying in horsepower and/or characteristics from those specified, he shall first submit his request for the change and shall then coordinate the change with all other parties (e.g. electrical contractor) and pay any costs associated with the change.
- C. Motor Controllers
1. Single Phase Manual Starters to 1 Hp and 120-277 V: Cutler Hammer MS with indicating light.
 2. 3-Phase: Full voltage, non-reversing, electro-mechanical, combination circuit breaker and motor controller, UL Listed, NEMA rated, 460V, 65,000 AIC, minimum 50 VA 24V controls transformer with secondary overcurrent protection, suitable for operation at -40°F to +149°F and specified voltage -15% to + 10%, adjustable solid state overloads initially set at Class 10, HOA switch, run indicator, two auxiliary contacts for remote monitoring of status, and enclosure for surface mounting. Cutler Hammer OAE.
 - a. Provide enclosure appropriate to the location:
 - 1) NEMA-1 for indoor dry locations.
 - 2) NEMA-3R for outdoors.
 - 3) NEMA-4 for wet applications.
 - 4) NEMA-12 for dusty locations.
 - 5) Explosion-proof – where required.
 - b. Motor controllers factory mounted and wired on AC units, boilers, etc, may be definite purpose, and need not have all the features specified here.
- D. Variable Speed Drives
1. General: Factory fabricated, variable voltage and frequency type for driving the specified AC motor in a typical HVAC variable torque application, listed per UL-508, and rated for installation within a return air plenum. Performance specified here is based on driving a 4-pole NEMA B induction motor. Select and size VFDs so they are compatible to drive motors with characteristics as indicated on the drawings.
 2. Conditions of Service: Suitable for installation and operation at 0 – 100% speed and load throughout the following conditions:
 - a. Electric Service: Indicated voltage +10% or -30%, voltage imbalance +/-3%, 48-63 Hz.
 - b. Ambient Temp & Humidity: 32-104°F and 0-95% RH non-condensing. Derate capacity 1% per 1.8°F above 104°F.
 - c. Elevation: As specified in Section 23 0500. Derate capacity 2% per 1000 ft above 3300 Ft elevation.
 - d. Output Cable: Up to 328 ft length or additional length if indicated on drawings.
 - e. Vibration: Rated per IEC 68-2-34/35/36.
 - f. Seismic: Certified and labeled to IBC [2009].
 3. Enclosure: NEMA-rated and suitable for mounting on a wall or Unistrut stand; zero clearance to obstructions on the sides and back; and conduit connection on top, bottom, back or sides (field selectable).
 4. Power Side: All required power components including 3-phase rectifier bridge, DC capacitor bank, and output IGBT. Manual bypass starter (if indicated in schedule): Electro-mechanical or electronic, 3-contact type, but with provisions to power VFD controls troubleshooting while operating on bypass starter.

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5. Controls: All required safety and operating controls, control transformer with secondary overload protection, removable and hot pluggable local control panel with LCD display. Fully programmable from the LCD display without the use of any additional devices. LCD shall be bright, easy to read, English language, engineering or SI units (set it up to display in engineering units), not utilizing codes or lookup tables. Provide the following functionality:
 - a. Automatic load-dependent carrier frequency control to optimize motor-drive efficiency, maximize motor life, and minimize motor heating. Automatically optimize between low speed switching (for reliable starts and smooth low speed operation) and high speed switching (to maximize drive efficiency).
 - b. Power failure auto restart.
 - c. Flying start to automatically synchronize power-up after voltage trip.
 - d. Drive over-temperature protection with automatic carrier frequency adjustment and automatic derate prior to tripping.
 - e. 3-phase output current sensing.
 - f. 1-3600 second manually adjustable acceleration and deceleration ramps with automatic over-ride to prevent overload.
 - g. Temperature-controlled VFD cooling fans.
 - h. PID controller.
 - i. Minimum three lockout frequencies.
 - j. Trickle current feature to allow current flow to prevent condensation when a motor is shut down.
 - k. Controls to prevent damage in the event that an input or output disconnect is opened while VFD is powering motor.
 - l. No load/broken belt warning.
 - m. Separate warnings for high frequency, low frequency, high current, low current.
 - n. Hold last state if analog control signal, RS-485 communication, or keypad control signal is lost.
 - o. Provisions for up to 4 digital inputs to trip the VFD, with programmable English-language display message on LCD (e.g., “Vibration Switch,” “Smoke Detector,” “Duct High Pressure,” etc).
 - p. Fault log storing the most recent ten faults with error code, time and value.
6. Protection: Motor thermal overload; short circuit, ground fault, heat sink high temperature cutout, high or low voltage on DC bus, loss of phase, motor-generated over-voltage, phase reversal.
7. Output
 - a. Voltage: 0 – 100% of motor rated voltage at any input voltage within the range given above.
 - b. Frequency: 0 – 120% of input frequency.
 - c. Minimum 96% efficiency at rated frequency and full load, and 80% efficiency at 50% speed.
 - d. Minimum 98% power factor at all speeds and loads.
 - e. Torque: Capable of the following torque output as a percentage on rated full speed torque: Breakaway: 160% for 0.5 seconds; Acceleration: 100%; Overload: 110%.
 - f. Audible Sound: Not to exceed the following dBA sound pressure when measured one meter from the VFD under any operating condition:

	<u>VFD</u>	
<u>Hp</u>	<u>NEMA 1</u>	<u>NEMA3R/12</u>
1 – 10	50	62
15-60	61	66

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- g. Harmonic Distortion Analysis: Supplier or manufacturer must have the capability to perform a computerized analysis of the electrical distribution system to determine the harmonic distortion generated by the VFDs. If such an analysis is requested, a change order will be issued to cover the associated costs. The Engineer will provide a CD of the electrical CADD files, and will define the harmonic distortion criteria to be met. Analyze different input line reactors or other approaches to address harmonic distortion, and recommend the most appropriate approach to meet these criteria.
- 8. Interface with the project's FMS (hard-wired, may be individual points or may be through the RS-485 communication port:
 - a. DIs: Start/stop (24VDC sourced from VFD).
 - b. DOs: Status, Common Alarm (Form C Relays, max 250VAC 2A).
 - c. AIs: Control signal (4-20 mA, 0-5 VDC, or 0-10 VDC).
 - d. AOs: Output speed (%), output current (%) (4-20 mA).
- 9. Safeties: Minimum two sets of terminals that can be wired to external safeties. When safety is energized VFD shall display a programmable alarm message (e.g., "Vibration Switch," "Fire Alarm", "High Static Pressure."
- 10. Startup: Provide startup by a factory-trained technician. Provide as many site visits as required to properly start VFDs and driven equipment. Coordinate with the controls contractor regarding proper interface with the FMS. Coordinate with the suppliers of the driven equipment, and program all lockout frequencies into the drive. Submit a startup report for each VFD. Where multiple VFDs are provided and for projects with phased construction, multiple site visits will be required. Instruct the Owner's operating personnel regarding VFD programming and operation.
- 11. Options & Accessories: Unfused disconnect, NEMA-3R enclosure, [5]% impedance input AC line reactor, EMI input filter, suitable for driving multiple motors with individual motor overloads as indicated on drawings, 100,000A short circuit interrupting rating, output inductor, LC filter, and RS-485 Serial Communication Port suitable for Bacnet, LonWorks, or Modbus.
- 12. Approved Manufacturers: Danfoss VLT 6000, ABB, Yaskawa, OAE.

2.3 ELECTRICAL WIRING AND CONTROL EQUIPMENT

- A. Provide wiring and conduit as scheduled in Section 23 0549.
- B. Coordinate with all disciplines to ensure that all necessary components of control work are included and fully understood.

2.4 IDENTIFICATION

- A. Scope: Identify all equipment, ductwork, valves, piping, and control devices shown on the Drawings, identified in the equipment schedules, and indicated in these Specifications. Provide submittals for products and procedures used for identification.
- B. Equipment: For all mechanical equipment supplied or installed under Division 23, provide an equipment identification tag or stencil unit number onto the equipment. Stencils shall be minimum 3-inch height, dark contrasting color, of a material suitable for the application.

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1. For rooftop HVAC equipment, provide a permanently affixed, weather-resistant label to identify the areas served.
- C. Ductwork: Identify ductwork at or near the fan with stenciled signs on insulated ductwork or engraved laminated plastic signs secured by rustproof screws on un-insulated ductwork. Sign shall identify air conditioning system or fan unit and area served.
- D. Control System Devices: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the Contract Drawings.

2.5 GENERAL CONSTRUCTION COMPONENTS

- A. Roof Curbs and Equipment Support Rails
 1. General: Factory fabricated, (see drawings for minimum height), galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction. Actual curb heights to be coordinated by contractor with roofing insulation height to maintain code-required height above final roofing elevation.
 2. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, RPS, OAE.
 3. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck, RPS, OAE.
- B. Access Doors (ADs)
 1. Steel frame and door, surface mounted, factory primed, 150o opening, flush, screw-driver operated cam lock, minimum 24" x 24" except as approved, but larger where required for proper access. Where ADs are installed in general construction with a pattern, match AD dimensions to this pattern. Milcor, Krueger, OAE.
 - a. Sheet Rock Wall or Ceiling: With drywall bead on frame, Milcor Style DW.
 - b. Plaster Wall or Ceiling: Milcor Style K.
 - c. Masonry Walls: Milcor Style M.
 - d. 1-hr and 2-hr rated walls: UL Listed for 1.5-hr Class B Fire Rating, self-closing and self-latching. Milcor Style UFR.
 - e. Suspended Ceilings: Milcor Style AT.
 - f. Fire Rated Suspended Ceilings: Milcor Style ATR.
- C. Painting: Finish painting of mechanical systems and equipment will be under Spec Section 09 9100, "Painting," unless equipment is specified to be provided with factory-applied finish coats.

2.6 MISCELLANEOUS PROVISIONS

- A. Flow Diagrams: Provide half-size prints of each system flow diagram, including air handling, steam, chilled water, heating water, domestic water, domestic HW, etc. Mount framed under plexiglass, and locate either on the associated AHU or on a nearby wall. Incorporate any as-built revisions.

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PART 3 - EXECUTION

3.1 INSTALLATION GENERAL REQUIREMENTS

- A. Cooperation with Other Trades: Refer to other parts of these Specifications covering the work of other trades which must be carried on in conjunction with the mechanical work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. Be responsible for the size and location of all openings, foundations, etc.
- B. Trenching and Backfilling: Provide all excavation, trenching and backfilling required for the installation of the work of this division.
- C. Manufacturer's Instructions: Install all products in accordance with manufacturers' recommendations and the requirements of any applicable listings. If manufacturers' recommendations and/or requirements of applicable listings conflict with plans and specifications, report such conflicts to the Owner's Representative.
- D. Field Measurements: Verify all dimensions and conditions governing the work. Examine adjoining work on which the work of this Division is dependent, and report any deficiencies.
- E. Do not compromise the building structural, fire resistant construction or vapor barrier system.
- F. Supports for Equipment and Systems: Foundations and structural supports for equipment will generally be provided by others. The contractor for this division shall provide supplementary supports as required to support equipment, distribution systems, and other components installed under this division. Prior to installing mechanical work, examine foundations and supports to ensure they are adequate to properly support the equipment. Provide all necessary foundations, structures, supports, inserts, sleeves, etc, for installation of mechanical and plumbing equipment, ductwork and piping, etc. Coordinate installation of such devices with all disciplines. Verify that the devices and supports are adequate as intended and do not overload the building structure.
- G. Concealed or Buried Work: For work which is underground or which will be concealed by building construction, provide digital photographs to document the installation throughout the construction project, but not less than weekly. Include plans indicating where the photographs were taken. Notify the OR of when the work will be complete and provide OR a minimum five-day period to inspect the work after completion but prior to when it is backfilled or concealed by building construction.
- H. Access Doors: Provide as required for access to valves, dampers, controls, or other items for which access is required for either operation or servicing. The type of access door shall be as required by the room finish schedule.
- I. Alignment of Flexible Couplings: Flexible couplings between motors and driven equipment shall be aligned by a qualified service technician after the equipment is installed and ready for operation. Align equipment per manufacturer's recommendations under operating conditions and temperature. Provide written certification that each device has been so aligned.
- J. Lubrication: Provide all oil for the operation of all equipment until acceptance. Be responsible for all damage to bearings while the equipment is being operated by Contractor up to the date of

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acceptance of the equipment. Protect all bearings and shafts during installation and thoroughly grease shafts to prevent corrosion. Bearings for items of mechanical equipment shall be marked at each bearing location as to whether the bearing is a sealed type or relubricable type unit.

- K. Tests: All tests shall be conducted in the presence of the designated and authorized Owner's Representative. Notify the Owner's one week in advance of all tests. Requirements for testing are specified under the sections covering the various systems. Provide all necessary equipment, materials, and labor to perform the required tests.
- L. Protection of Material and Equipment:
 - 1. Protect all work, materials and equipment furnished and installed under Division 23, whether incorporated in the building or not.
 - 2. All items of mechanical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner as approved.
 - 3. Protect all work and be responsible for all damage done to property, equipment and materials. Coordinate material storage with the Owner's Representative.
 - 4. Pipe and duct openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. Plumbing fixtures shall not be used by the construction forces. At the completion of the work clean and polish fixtures, equipment and materials prior to turning them over to the Owner.

3.2 DRAWINGS

- A. The drawings show the general arrangement of the piping, ductwork, equipment, etc. Follow them as closely as actual building construction and work of other trades will permit. Where discrepancies occur between Plans and Specifications, the more stringent shall govern. All Contract Documents shall be considered as part of the work. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories, which may be required, and no attempt has been made to do so. Rather, the drawings convey the general design intent. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing fittings, valves, and accessories as required to meet such conditions. Show any such changes on the Record Drawings.
- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, submit an RFI.
- C. Install equipment, piping, ductwork, and electrical systems with proper clearance for operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions, etc. Include proper clearance in front of and above electrical equipment as defined by the National Electric Code (NEC). Piping and ductwork systems shall not be routed through or above electrical equipment rooms, telecommunications rooms, elevator machine rooms, or electrical equipment spaces within mechanical equipment rooms.
- D. The unique design features of this project will necessitate that the contractor for this division provide greater than normal levels of coordination and cooperation with other disciplines.
- E. Arrange all concealed mechanical systems carefully to fit within the available space without interference with adjacent structural and electrical systems. Make all necessary provisions for

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penetrations of piping and ductwork, including sleeves and blockouts in structural systems. The exact location of all exposed mechanical systems, including grilles, registers, and diffusers; access doors; sprinkler heads; piping and ductwork exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it relates to the aesthetic design for the facility.

3.3 INTERRUPTING SERVICES

- A. Coordinate the installation of all work within the building in order to minimize interference with the operation of existing building mechanical, plumbing, fire protection, and utility systems during construction. Connections to existing systems requiring the interruption of service within the building shall be carefully coordinated with the Owner to minimize system downtimes. Requests for the interruption of existing services shall be submitted in writing a minimum of two weeks before the scheduled date. Absolutely no interruption of the existing services will be permitted without written review and authorization.

3.4 SEISMIC RESTRAINTS

- A. The Contractor shall be responsible for all anchors and connections for the mechanical work to the building structure to prevent damage of equipment and systems due to earthquakes. The complete fire protection systems shall be supported as required to resist stresses produced by lateral forces as required by NFPA No. 13. Where mechanical equipment, piping, and ductwork are connected to the building structure, exact method and means of attachment to the structural system shall be approved]
- B. See Section 23 0549 for requirements for seismic supporting of mechanical equipment and systems.

3.5 INSTALLATION CHECK

- A. An experienced, competent, and authorized representative of the equipment listed below shall visit the site of the work and inspect, check, adjust if necessary, and approve the installation for the equipment listed below. The equipment supplier's representative shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is approved and accepted.
- B. Each equipment supplier's representative shall furnish a written report certifying that the equipment (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and, (4) has been operated under full load conditions and that it has operated satisfactorily.
- C. Equipment requiring installation check includes the following:
 - 1. VAV Air Handling Units
 - 2. Facility Management System (See Division 25)

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3.6 OPERATION PRIOR TO ACCEPTANCE

- A. Operation of equipment and systems for the benefit of the Owner prior to substantial completion will be allowed provided that a written agreement between the Owner and the Contractor has established warranty and other responsibilities to the satisfaction of both parties.
- B. Operation of equipment and systems for the benefit of the Contractor, except for the purposes of testing and balancing, will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other responsibilities.

3.7 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

- A. At completion of the project, submit searchable PDFs of these documents electronically. Organize bound information in a logical fashion with a table of contents and bookmarks for the different sections. Organize PDFs in a logical fashion to assist the operating personnel in retrieving desired data. Provide minimum two 1-hour sessions to instruct Owner's facility personnel in how to find information in the PDFs. Take attendance and submit the attendance list to the Owner's Representative. Include the following:
 - 1. Approved Submittals.
 - 2. Test reports.
 - 3. O&M manuals and instructions covering all equipment supplied under this Division, with all non-applicable information crossed out. Clearly identify all required routine maintenance. Include parts lists.
 - 4. A master Lubrication Chart listing each piece of equipment, the recommended oil or grease, and the recommended frequency of lubrication.
 - 5. The names and addresses of at least one service agency capable of providing required maintenance for each item of equipment supplied.
 - 6. Complete temperature control diagrams including control descriptions, system sequence of operation, operating instructions, control system maintenance and calibration information, wiring diagrams, and all control setpoints. See Division 25 for additional requirements.
- B. Submit O&M manuals for review and distribution to the Owner not less than two weeks prior to the date scheduled for O&M instructions as specified.
- C. Demonstrate proper system operation to the owner's operating staff. Provide the services of the contractor and subcontractors (e.g., mechanical, T&B, temperature control, etc), as required to properly demonstrate system operation.
- D. Provide the necessary skilled labor and helpers to operate the mechanical systems and equipment for a period of 5 days of eight hours each. During this period, instruct the owner's facility staff fully in the operations, adjustment and maintenance of all equipment provided. Provide at least two weeks advanced notice, with a written schedule of each training session, the subject of the session, the Contractors' Representatives who plan to attend the session, and the time for each session. Take attendance and submit attendance sheets to the Owner's Representative.

3.8 RECORD DRAWINGS

- A. Maintain a full-size set of marked-up prints showing the installed location and arrangement of all work under this division, and in particular where changes were made during construction. Keep

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record drawings accurate and up-to-date throughout the construction period. Owner's Agents may request to review record drawings during construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFIs, bulletins, and change orders neatly taped or attached to record drawing set. At the completion of the project send the Engineer full-size plans clearly showing all changes from the original design marked up in red so as to facilitate the Engineer incorporating these changes into the Engineer's CADD files. Forward record drawings to the Owner's Representative prior to submitting a request for substantial completion. Submittal of shop drawings will not be an acceptable alternative for record drawings.

3.9 SITE VISITS AND OBSERVATION OF CONSTRUCTION

- A. The Engineer may make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the work so as to determine if such work is proceeding in general accordance with the Contract Documents. This observation will not release the Contractor from his responsibility to supervise, direct, and control all construction work and activities. The Engineer has no authority over, or responsibility for means, methods, techniques, sequences, or procedures of construction or for safety precautions and programs, or for failure of the Contractor to comply with applicable laws, regulations, or codes.
- B. Prior to substantial completion, request that the Engineer provide a final observation visit. Complete the attached "Final Observation Checklist," and include it with this request. For any items that are not applicable, mark them "N/A."

3.10 PROJECT CLOSEOUT

- A. Submit written certification that all work complies with the specifications and applicable codes. Submit certifications and acceptance certificates including proof of delivery of record drawings, O&M manuals, spare parts required, and equipment warranties.

END OF SECTION

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**CONTRACTOR'S MECHANICAL & PLUMBING CHECK LIST
(ALL APPLICABLE ITEMS MUST BE COMPLETED PRIOR TO FINAL OBSERVATION)**

Project: _____ Date Submitted: _____

General Contractor: _____ Date of Final Mechanical System: _____

Mechanical Contractor: _____ Observation Requested: _____

In advance of requesting a final mechanical observation for installed mechanical systems, please check all items that have been completed. For all items not applicable to this project mark N/A.

PLUMBING/PIPING

- _____ 1. All plumbing fixtures are set, sealed and cleaned.
- _____ 2. All domestic and HVAC pipe systems are insulated.
- _____ 3. All pipe systems are identified with specified labels and directional arrows.
- _____ 4. Floor sinks and drain grates are cleaned and debris removed
- _____ 5. Valve tags are installed.
- _____ 6. Special equipment (water softeners, water heaters, piping systems, etc.) have been checked and put into service.
- _____ 7. Medical gas systems have been checked and certified.
- _____ 8. Special piping systems have been cleaned and pressure tested.

- | | |
|----------------------|------------------------|
| _____ Fuel Handling | _____ Process Plumbing |
| _____ Compressed Air | _____ Nitrogen |
| _____ Natural Gas | _____ Vacuum |
| _____ Other | _____ Argon |
| _____ | _____ Medical Gas |
| _____ | _____ Other |
| _____ | _____ |

- _____ 9. Limestone chips have been installed in acid dilution sumps.
- _____ 10. Plumbing/piping connections have been completed to Owner-furnished equipment and equipment furnished by other Contractors/Subcontractors.
- _____ 11. Exterior wall hydrants have been cleaned.
- _____ 12. Concrete collars have been installed at clean-out to grade, valve box, or other specified plumbing items.
- _____ 13. Drains and relief lines from plumbing and HVAC equipment have been installed and secured in a proper manner.
- _____ 14. All plumbing equipment and areas of equipment have been cleaned and debris removed.
- _____ 15. All plumbing equipment required by the Specifications has been identified and/or numbered.
- _____ 16. Domestic water systems sterilization has been completed.
- _____ 17. Refrigerant piping/system has been charged and tested.

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- _____ 18. Strainers/suction diffusers have been cleaned.
- _____ 19. Backflow preventers have been tested.
- _____ 20. Air has been vented from all coils and systems.
- _____ 21. Water treatment systems have been charged and tested.

_____ Chilled Water	_____ Condensed Water
_____ Hot Water	_____ Steam/Condensate

- _____ 22. Ethylene glycol system has been charged with correct mixture and tested.
- _____ 23. Water systems have been cleaned (X) and pressure tested (P)

_____ Chilled Water	_____ Condenser Water
_____ Hot Water	_____ Non-Potable Water
_____ Steam	_____ Domestic Hot Water
_____ Condensate	_____ Domestic Cold Water
_____ Fire Protection	_____ Acid Waste and Vent
_____ Sanitary Sewer and Vent	_____ Heat Recovery Piping
_____ Roof and Overflow Drains	_____ Other (list)

- _____ 24. PRVs have been adjusted (water, steam gases).

FIRE PROTECTION

- _____ 1. Fire protection piping is completed.
- _____ 2. Fire protection system has been certified by the Fire Marshal's office.
- _____ 3. All electrical interlocks between the fire sprinkler components and the fire panel have been checked for operation.
- _____ 4. Spare sprinkler head, wrench and cabinet are installed.

HVAC - EQUIPMENT AND DUCTWORK

- _____ 1. All ductwork has been sealed and insulated.
- _____ 2. Return air paths and transfer openings have been verified.
- _____ 3. Air handlers have been cleaned inside and out and construction filters removed and replaced with final filters.
- _____ 4. All air handling equipment has been started and operated for the specified time.
- _____ 5. All equipment isolators have been adjusted for specified deflection.
- _____ 6. All VAV boxes, fan coils, or fan powered boxes are completed and operational.
- _____ 7. All pump shafts and couplings have been aligned.
- _____ 8. Ductwork, coils, housing, diffusers, registers and grilles have been cleaned.
- _____ 9. Boilers have been fired and certified by the supplier.
- _____ 10. Cooling towers have been started and inspected by the supplier.
- _____ 11. Chillers have been charged, started and certified for operation by the supplier.
- _____ 12. Fire dampers are accessible and fully operational.

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- _____ 13. All HVAC equipment has been lubricated.
- _____ 14. HVAC equipment has been labeled in accordance with the Specifications.
- _____ 15. Duct pressure testing is complete and accepted.
- _____ 16. "HAZARDOUS AREA" signed installed where applicable.
- _____ 17. Belt guards installed where applicable.
- _____ 18. Variable frequency drives have been tested by the manufacturer's representative and certified to be in compliance with all of the specified requirements.
- _____ 19. Testing and balancing has been completed, deficiencies noted have been corrected.
- _____ 20. Special systems have been started and tested, such as: Humidification, laboratory hoods, kitchen hoods, and Owner-furnished items.

TEMPERATURE CONTROLS

- _____ 1. Temperature control panels and devices have been labeled in accordance with the Specifications.
- _____ 2. All control dampers close completely and edge and blade seals form tight seal.
- _____ 3. All control valves have been piped as required by the Drawings.
- _____ 4. Controls systems are completed and all control points are operating and recording properly.
- _____ 5. All temperature control tubing and wiring is installed and secured in accordance with the Specifications and the electrical code.
- _____ 6. Smoke removal fans and/or smoke detectors have been tested for operation and shutdown.
- _____ 7. Freezestats have been tested ensuring fan shutdown and full damper closure.
- _____ 8. Operator training for temperature controls has taken place.
- _____ 9. Refrigerant sensors and equipment room shutdown have been tested.

GENERAL ITEMS

The following specified items have been submitted:

- _____ 1. Record Drawings (to be submitted prior to final payment to the Contractor).
- _____ 2. Operation and maintenance manuals.
- _____ 3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 23 0500).
- _____ 4. Testing and balancing reports.
- _____ 5. Test kits furnished to Owner.

- _____ Flow Measuring Devices
- _____ Flow Balance Valves
- _____ Flow Control Devices

- _____ 6. Temperature control schematics and sequence of operation.
- _____ 7. Wall-mounted lubrication, valve, and temperature control charts have been installed.

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DIVISION 23 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS

PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section _____ Page _____ Paragraph/Line _____ Specified Item _____

Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES NO

If YES, explain

2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES NO

3. List differences between proposed substitutions and specified item.

4. Does the substitution affect drawing dimensions? YES NO

5. What affect does substitution have on other trades?

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES NO

If YES, explain:

7. Will substitution affect progress schedule? YES NO

If YES, explain:

8. Will maintenance and service parts be locally available for substitution? YES NO

If YES, explain

9. Does proposed product contain asbestos in any form? YES NO

SUBMITTED BY: Firm:

Date:

Address:

Signature:

Telephone:

For Engineer's Use Only

Accepted _____	Not Accepted _____	Received Too Late _____
By: _____	Date: _____	
Remarks: _____		

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LICENSE, INDEMNITY AND WARRANTY AGREEMENT

BETWEEN Bridgers & Paxton Consulting Engineers
4600-C Montgomery Blvd NE
Albuquerque, NM 87109

And the Contractor **[NAME]**

[Address]

[Address]

For use of BIM – Building Information Modeling produced by Bridgers & Paxton Consulting Engineers, Inc. (B&P) in conjunction with the referenced project:

PROJECT: [Project Name and B&P Job #]

THE CONTRACTOR ACKNOWLEDGES THE FOLLOWING:

1. The model remains the property and control of B&P unless otherwise stipulated in separate contractual agreements with the Architect and/or Owner. Providing access to the model does not transfer copyright or ownership, and is a limited license to use in accordance with these and other conditions set by B&P. The Contract Documents do not require the Contractor to use the model to prepare drawings in electronic format for use during construction, or the use in any way of BIM or CAD systems. The Contractor is not permitted to make alterations to the design model and/or the information contained therein without prior approval from B&P.
2. The model and the information contained is provided as is, the Revit Version 2014 (or earlier version as required by the project) format used by B&P. The model is provided without warranty or guaranty of compatibility with the Contractor’s software or hardware systems. Further, the Contractor acknowledges data stored within the model can be altered, wither intentionally or unintentionally, by transcription, machine error, environmental factors, duration, and method of storage, and/or computer operators.
3. The model, and the information contained therein is provided for the Contractor’s convenience only, is not a Contract Document and does not relieve the Contractor from the requirements of the Contract Documents. The information provided in the model may not reflect the Contract Documents in all areas and the Contractor will be required to verify where changes have occurred. Also, field verification of existing and as-built conditions are required as part of a submittal process as applicable per project requirements. The official Contract Document set will be used as the precedent and authoritative document, and, in comparison with electronic files, shall supersede any discrepancies, omissions, or errors shown on the electronic files.
4. The design model may contain information provided by others. B&P cannot guarantee or warrant the accuracy and completeness of information provided by others.
5. The information provided in the model is only diagrammatic reflecting design intent. Contract Documents require that the work and coordinated shop drawings reflect actual field verified conditions with actual equipment/duct sizes, utility locations, and related site/project conditions.
6. The Contractor accepts responsibility for ensuring all persons, including sub-contractors, using the model complies with the requirements and limitations in using the information provided to them. Further, the use

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of the model is limited solely to this project. Use of the model or contents within on other projects or on other applications by the Contractor is expressly prohibited.

7. This Hold Harmless Agreement shall be attached to and transmitted with the design model at all times so that all those that the Contractor allows to have access are bound by the terms of this Agreement.

ACKNOWLEDGEMENT

1 By accepting the design model and the above stipulations, the Contractor and its agents, employees, Subcontractors of any tier, material suppliers or any others that Contractor allows to access the model agrees to defend, indemnify and hold harmless the Owner and Bridgers & Paxton Consulting Engineers, Inc., their agents, employees against all claims, liabilities, damages, losses, expenses and costs (including expert and attorney's fees) (Claims) arising from, relating to or resulting from their use of the design model (BIM).

**ACCEPTED:
CONTRACTOR REPRESENTATIVE**

Authorized Signature: _____

Title: _____

Date: _____

BRIDGERS & PAXTON CONSULTING ENGINEERS

Authorized Signature: _____

Title: _____

Date: _____

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SECTION 23 0501 – DEMOLITION

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

1.2 RELATED SECTIONS

- A. See Section 23 0500, for Common Work Requirements for HVAC.
- B. See Division 1, for Cutting and Patching.

1.3 SCOPE OF WORK

- A. The terms "demolish" and "remove" shall mean disconnect, cart away, and dispose of offsite. Components to be demolished or removed include all materials, equipment, building construction, and other components as indicated. Components to be demolished shall become the property of the contractor, and contractor may dispose of them by either landfilling or by selling salvageable parts and recyclable materials to legitimate third parties.
- B. Except as specifically noted, asbestos abatement will be by others, and is not included in this contract. Advise Owner sufficiently in advance of demolition work so that Owner may arrange to have asbestos removed without delaying demolition or construction work.
- C. The Owner retains the first right of refusal on all components to be removed. When requested, remove components carefully and deposit components in locations as directed by the Owner.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 GENERAL

- A. Within four weeks after notice to proceed, and a minimum of two weeks prior to any demolition activities, submit a project schedule indicating all demolition work. Schedule all work to minimize interruptions in utility services to the facility. Interruptions generally will be allowed only outside normal operating hours. Sequence all work in accordance with the drawings and the Project Manual.

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- B. Take care not to damage equipment, materials, components, and building construction which is to remain in service. Provide blind flanges, caps, etc, so as to prevent accidental discharge of water, etc.
- C. Do not interfere with the Owner's access to buildings and equipment. If any activities cause interference which is objectionable to the Owner, contractor shall modify his means and methods, or reschedule those activities outside occupied hours at no additional cost to the Owner.
- D. Where existing systems must remain in service during the construction project, make whatever provisions are necessary to accomplish this. This includes providing blind flanges and caps, temporary insulation, duct caps, etc, to allow for proper system operation.

3.2 **EQUIPMENT**

- A. General: Disconnect and remove piping, ductwork, controls, power, and equipment supports. Wherever possible, remove equipment as a whole. Do not cut up equipment in place unless approved in advance by the Owner.
- B. Chillers: Drain water in evaporator and condenser to sanitary sewer system. Remove refrigerant and either recycle or dispose of as a hazardous material. Remove oil and dispose of as a hazardous material. Comply with all applicable regulations, including the Clean Air Act and RCRA. Submit documentation showing final owner and location of refrigerant and oil.
- C. Boilers: Water in boiler, condensate system, and boiler feed system may be drained and disposed of in accordance with applicable regulations. Remove boilers, steam piping, blowdown systems, condensate piping, condensate pumps, boiler feed pumps, safety relief piping, breeching, stacks, and all associated piping and accessories. Repair concrete floor. Remove chemicals and chemical feed equipment. Chemicals shall be properly disposed of in accordance with all applicable regulations including RCRA. Submit documentation showing final owner, location, and means of disposal for chemicals.

3.3 **PIPING**

- A. Disconnect piping as indicated, and remove all piping not required in the final, upgraded condition of the systems. This includes removal back to the headers and mains which must remain in service. The existing valving may not hold tight. Arrange in advance for shutdowns as required. Provide caps, blind flanges, etc. as indicated on drawings, as required to facilitate construction activities, and as required to facilitate owner's use of the system.
- B. Remove all components in piping system, including valves, fittings, flanges, strainers, anchors, guides, hangers, supports, supplementary steel, attachments to structure, instrumentation, insulation, etc.
- C. Patch all openings in walls, floors, roofs, partitions, gratings, etc, which remain after piping is removed.

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3.4 DUCTWORK

- A. Disconnect ductwork as indicated, and remove all ductwork not required in the final, upgraded condition of the systems. This includes removal back to the mains which will remain in service. Arrange in advance for shutdowns as required. Provide caps as indicated on drawings, as required to facilitate construction activities, and as required to facilitate the Owner's temporary and final use of the systems.
- B. Remove all components in ductwork system including fittings, dampers, grilles, registers, diffusers, louvers, hangers, supports, supplementary steel, attachments to structure, instrumentation, insulation, acoustic lining, etc.
- C. Patch all openings in walls, floors, roofs, partitions, gratings, etc, which remain after ductwork is removed.

3.5 CONTROLS

- A. Remove all controls associated with equipment, piping and ductwork which are to be removed. Controls shall include instrumentation, control panels, wiring, conduits, tubing, supports, and attachments to structure. Where wiring is run in conduit in concealed locations, remove the wiring, cap both ends of conduit, and label conduit as "ABANDONED" at both ends.

3.6 ELECTRIC POWER

- A. Remove all electric power associated with equipment, controls and accessories which are to be removed. Electric power shall include starters, disconnects, wiring and conduit from MCC's and distribution panels to local starters and disconnects, wiring and conduit from local starters and disconnects to equipment, supports, attachments to structure, and concrete housekeeping pads. Label all associated breakers as "SPARE." Where MCC's serve equipment to be removed and no new equipment is to be served from the same starter, leave the starter in place and label it as "Spare Size X Starter."
- B. Where wiring runs in conduit within concealed locations, remove the conductors, cap both ends of conduit, and label conduit as "ABANDONED" at both ends. Where wiring runs below grade, remove conductors, cap conduit at both ends, and abandon in place. Where wiring runs below concrete floor slabs, chip out concrete around conduit, remove conduit to bottom of slab level, and patch floor to match adjacent surfaces.

3.7 EQUIPMENT SUPPORTS

- A. Housekeeping Pads: Remove housekeeping pads for equipment to be removed. Remove all tripping hazards and resurface floor to match surrounding floor.
- B. Equipment Foundations: Remove foundations, remove all tripping hazards, backfill as required, compact to 95% Standard Proctor Density, and pour floor slab to match existing.
- C. Support Steel: Remove all support steel including attachments to building or to grade.

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3.8 **MEANS OF ACCESS**

- A. Remove all service platforms, catwalks, ladders, etc. which are required solely for the equipment, valves, and instrumentation which are being removed as part of this work.

END OF SECTION

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SECTION 23 0548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with the applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.

1.3 SCOPE

- A. It shall be understood that the requirements for seismic restraints are in addition to other requirements as specified elsewhere for the support and attachment of equipment and mechanical services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements for seismic restraint as specified herein, shown on the drawings and required by Code.
- B. The work under this section shall include furnishing all labor, materials, tools, appliances and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed and/or scheduled on the drawings and/or specified in this section of the specifications.
- C. The materials and systems specified in this section shall be provided by the Contractor from a single Seismic Snubber Restraint Materials Manufacturer to assure sole source responsibility for the performance of the seismic restraints used.
- D. The seismic snubber restraint materials manufacturer shall be responsible for detailed design for seismic supports, including calculation for size and attachment, signed and sealed by registered State of New Mexico Structural Engineer.

1.4 SUBMITTALS

- A. See Section 23 0500 for general requirements for submittal materials. In addition to the requirements contained in Section 23 0500, provide submittal information for all products and materials covered under this Section of the Specifications as listed herein.
- B. Furnish complete catalog data on all vibration isolators, restraints, and equipment vibration bases to be utilized for the project in order to establish compliance with the plans and specifications and all code requirements.
- C. Furnish complete shop drawing information including construction details for all vibration bases; support points and anchor bolt requirements and locations; method of support for piping and

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ductwork; method of isolation for piping and ductwork passing through the building structure; and location and arrangement of seismic restraints.

- D. Manufacturers not listed as approved in 'Part 2 - Products' of this section must submit for prior approval in accordance with provisions contained in Section 23 0500.
- E. Drawings shall be reviewed and certified by a registered Professional Engineer, with a minimum of five (5) years working experience in this field, certifying that the submitted seismic restraint system design and anchorage details complies with all specification requirements and applicable codes.

1.5 CODE REQUIREMENTS

- A. Seismic restraints shall be provided for equipment, materials and systems furnished and installed under Division 23 of this Specification in accordance with the requirements of the 2006 International Building Code; and NFPA No. 13 for fire protection system as adopted and interpreted by the State of New Mexico and the City of Alamogordo, for Seismic Zone ____ and for 'Critical Facilities'.

1.6 SEISMIC RESTRAINT REQUIREMENTS

- A. The Contractor shall submit calculations prepared by a State of New Mexico licensed Structural Engineer to substantiate that all items of mechanical equipment, ductwork and piping systems are properly supported to resist earthquake forces as required herein.
- B. All mechanical equipment mounted on vibration isolators shall be provided with seismic restraints securely anchored to the building structure capable of resisting horizontal forces of 100% of their weight and/or in accordance with IBC Requirements for Seismic Zone .
- C. All items of mechanical equipment required for life safety including the fire pump and fire protection systems shall be provided with seismic restraints securely anchored to the building capable of resisting horizontal forces of 100% of their weight and/or in accordance with IBC Requirements for Seismic Zone .
- D. All items of mechanical equipment, except as specified above, and all piping and ductwork furnished and installed under Division 23 shall be provided with seismic restraints securely anchored to the building capable of resisting horizontal forces of 50% of their weight.
- E. Seismic restraint/snubber manufacturer shall be responsible for the structural design of attachment hardware as required to attach seismic restraints/snubbers to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.
- F. The Contractor shall furnish a complete set of approved shop drawings of all mechanical and electrical equipment which is to be restrained to the seismic restraint manufacturer, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length and width dimensions, installed operating weights of the equipment to be restrained and the distribution of weight at the restraint points.

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PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Floor mounted vibration isolators shall be either spring isolators designed for seismic restraint application or pre-compressed molded fiberglass or ribbed neoprene units as specified herein and in the Mechanical Equipment Schedule on the drawings. All vibration isolated equipment shall employ seismic snubbers having an approved "R" rating issued by the State of New Mexico.
- B. Hanger type vibration isolators shall consist of steel springs in series with neoprene element as scheduled and specified on the drawings.
- C. All vibration isolation devices shall be furnished by a single manufacturer to assure sole source responsibility for the proper performance of the materials used.
- D. Vibration isolators shall be provided to maintain a minimum of 1-inch operating clearance.
- E. Vibration isolators shall have a minimum static deflection as specified on the drawings. Isolators shall be selected by the manufacturer for non-resonance with the equipment forcing frequency and the building structure's natural frequencies. Isolators shall be provided for suitable mounting to equipment and supporting structure.
- F. Vibration isolators shall be furnished by Kinetics Noise Control, Mason, or equivalent.

2.2 FLEXIBLE CONNECTIONS

- A. Flexible connections for piping systems shall be as specified in Section 23 0504. Flexible connection for fan equipment and flexible ductwork shall be as specified in Section 23 3000.

2.3 SEISMIC SNUBBER TYPES

- A. Reference: ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) Handbook, 2007 HVAC Applications, Chapter 54 'Seismic and Wind Restraint Design'.
- B. Type A: Coil Spring Isolator Incorporated within a Ductile Iron or Cast Aluminum Housing:
 - 1. Cast iron or aluminum housing are brittle when subjected to shock loading and are therefore not approved for seismic restraint applications.
- C. Type B: Coil Spring Isolator Incorporated within a Steel Housing:
 - 1. Spring isolators shall be seismic control restrained spring isolators, incorporating a single or multiple coil spring element, having all of the characteristics of free standing coil spring isolators as specified in the vibration isolation portion of this specification. Springs shall be restrained using a housing engineered to limit both lateral and vertical movement of the supported equipment during an earthquake without degrading the vibration isolation capabilities of the spring during normal equipment operating conditions.
 - 2. Vibration isolators shall incorporate a steel housing and neoprene snubbing grommet system designed to limit motion to no more than 1/4" in any direction and to prevent any

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direct metal-to-metal contact between the supported member and the fixed restraint housing. The restraining system shall be designed to withstand the seismic design forces in any lateral or vertical direction without yield or failure. Where the capacity of the anchorage hardware in concrete is inadequate for the required seismic loadings, an adapter baseplate to allow the addition of more or larger anchors will be fitted to fulfill these requirements. In addition to the primary isolation coil spring, the load path will include a minimum 1/4" thick neoprene pad.

3. Spring elements shall be color coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy power coated and shall have a minimum of a 1,000 hour rating when tested in accordance with ASTM B-117.
4. To facilitate servicing, the isolator will be designed in such a way that the coil spring element can be removed without the requirement to lift or otherwise disturb the supported equipment.
5. Spring isolators shall be Model FHS or FMS Isolator/restraint as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.

D. Type C: Coil Spring Isolator Incorporated within a Steel Housing:

1. Spring isolators shall be seismic control restrained spring isolators, incorporating one or more coil spring elements, having all of the characteristics of free standing coil spring isolators per the vibration isolation section of this specification, for equipment which is subject to load variations and/or large external forces. Isolators shall consist of one or more laterally stable steel coil springs assembled into fabricated welded steel housings designed to limit movement of the supported equipment in all directions.
2. Housing assembly shall be made of fabricated steel members and shall consist of a top load plate complete with adjusting and leveling bolts, adjustable vertical restraints, isolation washers, and a bottom load plate with internal non-skid isolation pads and holes for anchoring the housing to the supporting structure. Housing shall be hot dipped galvanized for outdoor corrosion resistance. Housing shall be designed to provide a constant free and operating height within 1/8".
3. The isolator housing shall be designed to withstand the project design seismic forces in all directions.
4. Coil spring elements shall be selected to provide static deflections as shown on the vibration isolation schedule or as indicated or required in the project documents. Spring elements shall be color coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy powder coated and shall have a minimum of 1,000 hour rating when tested in accordance with ASTM B-117.
5. Spring isolators shall be Model FLSS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as specified herein.

E. Type D: Coil Spring Isolator Incorporated within a Steel Housing:

1. Spring isolators shall be lateral restrained spring isolators, incorporating a single coil spring element, having all of the characteristics of free standing coil spring isolators as previously specified. Springs shall be assembled into a welded steel housing engineered to limit lateral movement of supported equipment during an earthquake without degrading the vibration isolation capabilities of the spring during normal operating conditions.

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2. Vibration isolators shall incorporate a steel angle and plate motion limiting assembly and steel coil spring, designed as a system to accept a force in any lateral direction in excess of the design seismic requirement for the isolator without yield or failure. Isolator shall limit lateral movement of the equipment to less than 1/4" in any direction. The lateral limit stop shall incorporate a neoprene grommet to prevent the potential for metal-to-metal contact. The vibration isolation element shall include a 1/4" thick ribbed neoprene noise stop pad, positioned outside of the housing anchorage path. The housing shall incorporate drilled holes for attachment to the supporting structure.
 3. Spring isolators shall be Model FYS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as specified herein.
- F. Type E: All Direction Neoprene Isolator:
1. Vibration isolators shall be neoprene, molded from oil resistant compounds, designed to operate within the strain limits of the isolator so to provide the maximum isolation and longest life expectancy possible using neoprene compounds. Isolators shall include encapsulated cast-in-place top steel load transfer plate for bolting to equipment and a steel baseplate with anchor holes for bolting to the supporting structure. Ductile iron or cast aluminum components are not acceptable alternatives and shall not be used due to brittleness when subjected to shock loading.
 2. Isolator shall be capable of withstanding the design seismic loads in all directions with no metal-to-metal contact.
 3. Isolator shall have minimum operating static deflections as shown on the project vibration isolation schedule or as otherwise indicated in the project documents and shall not exceed published load capacities.
 4. Neoprene isolators shall be Model RQ as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as specified herein.
- G. Type F: All Direction External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive movement during a seismic event by the use of 3-axis resilient snubbers, designed to withstand the project required seismic forces.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of 1/4" in any direction.
 3. Snubbers shall include a minimum of 1/4" thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Maximum neoprene bearing pressure shall not exceed 1500 pounds/Sq. Inch. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 4. Three-axis seismic snubbers shall be Model HS-5/7 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- H. Type G: All Direction Lateral External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive lateral movement during a seismic event by the use of 2-axis horizontal resilient snubbers, designed to withstand the project required seismic forces.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location to a maximum of 1/4".
 3. Snubbers shall include a minimum of 1/4" thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed

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only after the isolated equipment is mounted, piped and operating so as to ensure that no contact occurs during normal equipment operation.

4. Two-axis lateral seismic snubbers shall be Model HS-2 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- I. Type H: Two-Axis External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive vertical and horizontal movement during a seismic event by the use of 2-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of four (4) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all three directions.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of 1/4" in any direction.
 3. Snubbers shall include resilient neoprene pads within a minimum thickness of 1/4" to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 4. Two-axis seismic snubbers shall be Model HS-4 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- J. Type I: Single-Axis External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive horizontal one-axis movement during a seismic event by the use of single-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of four (4) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all lateral directions.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location in the direction of impact to a maximum of 1/4".
 3. Snubbers shall include resilient neoprene pads within a minimum thickness of 1/4" to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 4. Single-axis seismic snubbers shall be Model HS-1 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- K. Type J: Cable Restraints for Suspended Piping and Ductwork:
1. Seismic wire rope cable restraints shall consist of steel wire strand cables, sized to resist seismic loads, arranged so to offer seismic restraint capabilities for piping, ductwork, and suspended equipment in all lateral directions.
 2. End connection fittings shall be designed to swivel in order to ensure proper cable alignment and to avoid bending of rope. Protective thimbles shall be used at connection points so to eliminate bending cable across sharp edges.
 3. Anchoring hardware at each end of the cable shall be designed so to exceed the working project design load of the wire cable by a minimum of 50 percent.
 4. Seismic cable restraints shall be Model SCR as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.

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2.4 SEISMIC RESTRAINTS

- A. Seismic restraints shall be furnished and installed as specified herein and as required. Installation of all seismic restraint materials specified herein shall be accomplished following the manufacturer's written instructions. Installation instructions shall be submitted to the Engineer for approval prior to the beginning of the work.
- B. All mechanical equipment not mounted on spring isolators shall be provided with seismic restraints, as specified and detailed on the drawings, designed to restrain movement in vertical and horizontal directions during a seismic condition.
- C. All ductwork, piping systems, and suspended equipment including air terminal units shall be supported to resist seismic forces in accordance with SMACNA guidelines or by means of an approved bracing system equivalent to Kinetics, Pipe Shields Incorporated, or Mason. The seismic restraint manufacturer shall provide documentation on maximum restraint spacing for various cable sizes and anchors, as well as worst case reaction levels at restraint locations.
- D. All seismic snubber restraint assemblies shall meet the following minimum requirements:
 - 1. Impact surface should have a high quality elastomeric facing so to ensure that no metal-to-metal contact can occur.
 - 2. Resilient material should be easy to visually inspect for damage and be replaceable if necessary.
 - a. Resilient material used in snubber assemblies to be a minimum of 0.25" thick.
 - b. Resilient material used in snubber grommets to be a minimum of 0.12" thick.
 - 3. Assembly must be designed to offer seismic restraint in all directions, unless otherwise noted below.
 - 4. Clearance between resilient material and contacting isolated equipment surface must not exceed 0.25".
 - 5. Seismic restraints capacities to be verified by an independent test laboratory or certified by a registered State of New Mexico Structural Engineer who is experienced in seismic restraint design to ensure that the design intent of this specification is realized.
- E. The Contractor shall ensure that all housekeeping pads used are adequately reinforced and are properly attached to the building structural flooring, so to withstand anticipated seismic forces. In addition, the size of the housekeeping pad is to be coordinated with the seismic restraint manufacturer so to ensure that adequate edge distances exist in order to obtain desired design anchor capabilities.

PART 3 - EXECUTION

3.1 GENERAL

- A. All mechanical equipment scheduled on the drawings shall be isolated from building structure by means of resilient vibration and noise isolators supplied by a single manufacturer to the Contractor. The isolator manufacturer shall submit a tabulation of the design data on the isolators including spring O.D., free operating and solid heights of springs, free and operating heights of neoprene isolators. Static deflection scheduled is the minimum acceptable and represents the static deflection required based on the combined weight of the equipment; motor bases and any other accessories specified in the mechanical equipment schedule. Isolation bases shall be

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furnished by the Vibration Isolator Manufacturer. Vibration isolation system shall have a maximum lateral motion under equipment start-up and shutdown conditions of 1/4-inch. Restrain excess motion by spring type mountings. Connections to equipment shall allow for deflections equal to or greater than equipment deflections.

- B. Seismic restraints shall be in accordance with the State of New Mexico requirements and the Uniform Building Code, and shall be designed to resist seismic forces of magnitudes as specified herein. Installation of seismic restraints shall follow SMACNA guidelines.
- C. The Contractor shall coordinate the installation of the vibration isolation and seismic restraint devices with all trades and subcontractors. Contractor shall verify with the Architect that the devices and supports are adequate as intended and do not overload the building structural components in any way. The exact method and means of connection of the mechanical system to the building structural system shall be approved by the Architect.
- D. Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer's written instructions.
- E. Upon completion of installation of all seismic restraint materials and before start up of restrained equipment, all debris shall be cleaned from beneath all protected equipment, leaving equipment free to contact snubbers.
- F. No rigid connections between the equipment and the building structure shall be made which degrades the seismic restraint system herein specified. All electrical conduit to restrained equipment shall be looped to allow free motion of equipment without damage to the electrical wiring.

3.2 **EQUIPMENT CONNECTIONS**

- A. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified.
- B. Electrical circuit connections to isolated equipment shall be looped to allow free motion of isolated equipment; see Division 26.
- C. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.

3.3 **EQUIPMENT ISOLATORS**

- A. The minimum operating clearance between the equipment frame or the equipment vibration base frame and the housekeeping pad or floor shall be 1".
- B. The equipment vibration base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.

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- C. After the entire installation is complete and under full operational load, the isolator shall be adjusted so that the load is transferred from the blocks to the isolator. When all isolators are properly adjusted, the blocks or shims shall be free and shall be removed.
- D. Isolator static deflection shall be (minimum) as specified or scheduled on the Drawings.
- E. Position all corner or side seismic restraints with equipment operation for proper operating clearance and weld or bolt seismic restraint to seismic anchor plates in housekeeping pad.
- F. Install equipment with flexibility in piping and wiring connections.
- G. Verify all installed isolators and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to limit start-up equipment lateral motion to 1/4".
- H. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators or seismic restraints.

3.4 SEISMIC RESTRAINT FOR PIPING

- A. Seismically restrain all piping listed below. Use Type 'J' cable restraints for all piping supported by vibration isolation hanger assemblies, including:
 - 1. Natural gas piping, medical gas piping, vacuum piping, petroleum based liquid piping, and compressed air piping equal to or greater than 1" in inside diameter.
 - 2. All piping located within mechanical equipment and service rooms equal to or greater than 1-1/4" in inside diameter.
 - 3. All other piping equal to or greater than 2-1/2" in inside diameter.
- B. Type 'J' cable seismic restraint sizes, quantities, locations and mounting details per SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) 'Seismic Restraint Manual Guidelines for Mechanical Systems,' Latest Edition.

3.5 SEISMIC RESTRAINT FOR DUCTWORK

- A. Seismically restrain all ductwork listed below. Use Type 'J' cable restraints or equivalent for all ductwork, including:
 - 1. All rectangular and oval ducts with cross sectional area equal to or greater than 6 square feet.
 - 2. All round ducts with diameters equal to or greater than 28".
 - 3. Type 'J' cable seismic restraint sizes, quantities, locations and mounting details per SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) 'Seismic Restraint Manual Guidelines for Mechanical Systems', Latest Edition.

3.6 SEISMIC RESTRAINT FOR FIRE PROTECTION PIPING

- A. Fire protection, sprinkler piping and related equipment is considered as 'Life Safety Equipment' and shall be seismically restrained per guidelines as published by NFPA (National Fire Protection Association) as specified in Division 21.

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3.7 PIPING, DUCTWORK AND CONDUIT EXCLUSIONS

- A. Per the IBC (International Building Code), piping and ductwork which have diameter or cross sectional areas less than those noted in Sections 3.4, 3.5, and 3.6 do not require additional seismic restraint over and above the normal suspension hardware.

3.8 INSPECTION

- A. The Contractor shall notify the local representative of the seismic restraint materials manufacturer's representative prior to installing any seismic restraint devices. The Contractor shall seek the representative's guidance in all installation procedures.
- B. The local representative of the seismic restraint and snubber materials manufacturer shall conduct periodic inspections, minimum of monthly during construction period for equipment, piping and ductwork seismic restraint system installation. Inspection reports shall be in writing to the Contractor any deviations from good installation practice observed. These reports shall be forwarded to the Architect for review.
- C. On completion of installation of all seismic restraint and vibration isolation devices herein specified, the vibration isolation manufacturer shall inspect the completed system and submit an inspection report to the Architect. This report shall identify any installation error, improperly selected isolation devices, or other problems that could affect the performance of the system. The manufacturer's report shall include recommendations for any actions required to properly complete the vibration isolation and seismic restraint work. The cost of the inspection shall be included in the contractor's bid price.
- D. The installing Contractor shall submit a final report to the Project Architect and/or Engineer, including the manufacturer representative's final report, certifying that all seismic restraint material has been properly installed, or steps to be taken by the Contractor to properly complete the seismic restraint work per the specifications.

END OF SECTION

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SECTION 23 0549 HVAC AND ELECTRICAL INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Division 26 for Electrical.
- C. Division 28 for Electronic Safety and Security.

1.3 SCOPE

- A. It is the intention of this section to summarize the coordination of effort defined in the related sections and divisions of this specification.
- B. If there is a conflict between this Section and other Sections and Divisions of this specification, this Section shall be the governing and decisive Section.
- C. Make all connections to motors and controls for equipment supplied and/or installed under Division 23 according to Table 1 on the following page.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. No work shall be performed until the reviewed and marked submittal data have been reissued to the Contractor, unless written permission is obtained from the Engineer.

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TABLE 1

Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
Equipment Motors		Div. 23	Div. 23	Div. 26	N/A
Motor Control Center Including Starters, Pilot Lights, Heater, Switches, Auxiliary Contacts, and Internal Control Wiring		Div. 26	Div. 26	Div. 26	Div. 25
Stand Alone Motor Starters (outside motor control centers)	(1)	Div. 26	Div. 26	Div. 26	Div. 25
Variable Frequency Drives (VFD's)		Div. 23	Div. 23	Div. 26	Div. 25
Fused and Non-Fused Disconnects	(1)	Div. 26	Div. 26	Div. 26	N/A
Control Relays & Control Transformers	(1)	Div. 23	Div. 23	Div. 26	Div. 25
Cooling Tower Vibration Switches		Div. 23	Div. 23	Div. 26	N/A
Fan Coil Units		Div. 23	Div. 23	Div. 26	Div. 23
Min. Outside Air Units Including Mixing Dampers		Div. 23	Div. 23	Div. 26	Div. 25
Rooftop A/C Units Including Mixing Dampers		Div. 23	Div. 23	Div. 26	Div. 25
HVAC Unit Smoke Detectors		Div. 28	Div. 23	Div. 28	Div. 28
Fire/Smoke Control Dampers & Smoke Dampers		Div. 23	Div. 23	Div. 26	Div. 28
Fan Coil Unit Condensate Float Switches		Div. 23	Div. 23	N/A	Div. 25
Supply, Return & Exhaust Fan with unit mounted 115 VAC 2-position damper actuators interlock with fan motor/starter		Div. 23	Div. 23	Div. 26	N/A
Non-FMS Control Devices Including Wall Switches, Timers, Thermostats		Div. 23	Div. 23	Div. 26	Div. 26
Facility Management System (FMS)	(2)	Div. 25	Div. 25	Div. 25	Div. 25
Fire Alarm System & Interface w/HVAC System		Div. 28	Div. 28	Div. 28	N/A

TABLE NOTES:

1. Unless specified to be supplied with the equipment
2. Division 26 shall provide 120 VAC power to each mechanical space and the central plant as indicated on the drawings. Any additional power, transformers, and distribution shall be provided by the Section or Division indicated.
3. Division 23 indicates the HVAC contractor or their designated representative including equipment suppliers, sub-contractors, etc. Division 25 indicates the Integrated Automation Contractor.

END OF SECTION

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SECTION 23 0593 – TESTING, ADJUSTING AND BALANCING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 GENERAL

- A. Conform with applicable provisions of the General Provisions and the General Requirements.
- B. The TAB Agency's efforts shall be paid for by the Contractor and included in the mechanical contract price.
- C. Unless specifically noted, all work specified in this section shall be included in the scope of the TAB Agency's work. But some work described in this section is to be performed by the mechanical contractor, controls contractor, or others, and that work is specifically noted to be by these entities.

1.2 SCOPE

- A. Provide TAB for the systems and equipment installed under Division 23, including but not limited to:
 - 1. Supply and exhaust air systems including process systems.
 - 2. Return air where specifically noted.
- B. Provide all labor, instruments, and tools necessary to test, adjust and balance the systems shown on the drawings and/or described in these specifications. Check equipment performance, take measurements, adjust systems and equipment to provide specified performance, and report results. Submit reports to keep all parties posted on the progress of the TAB work.
- C. Where the TAB effort indicates deficiencies in system performance, TAB Contractor shall take the lead in a collaborative effort to trouble-shoot and resolve these deficiencies. Engage the assistance of others where necessary, starting with the Mechanical Contractor and Controls Subcontractor. Take additional measurements as required to identify the cause of the deficiencies, perform additional TAB as required to bring the system in compliance with the design intent. Engage the assistance of the Engineer and others where necessary. Indicate final setpoints and readings in a final TAB report.
- D. Include three days of effort on site for tests and/or balancing as directed in writing by the Owner's Representative beyond that described herein, but prior to substantial completion.
- E. Include two days on site for TAB efforts as directed in writing by the Owner's Representative after substantial completion.

1.3 STANDARDS AND DEFINITIONS

- A. Perform all work in accordance with these specifications and the latest edition of the NEBB Standards.

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- B. Air Handling Unit: Where the term Air Handling Unit (AHU) is used in this spec section, it shall include any factory fabricated or field erected unit that includes a fan and other components which filter, heat, cool, humidify or dehumidify the air stream. But the term AHU, where used in this section, does not include fan powered terminal units, fan coil units, unit heaters, cabinet unit heaters, etc.
- C. Air Handling System: A fan or AHU and ductwork.
- D. Record or Report: Where used as a verb, these terms mean to include in the TAB report.

1.4 QUALIFICATIONS

- A. TAB agencies shall meet the following qualifications:
 - 1. Membership in the Associated Air Balance Council (AABC), National Environmental Balance Bureau (NEBB) or the Testing, Adjusting and Balancing Bureau (TABB).
 - 2. An office located within a 200 mile radius of the project site.
 - 3. A minimum of five (5) years experience in the TAB field.
- B. The following TAB Agencies are prior approved:
 - 1. **NEW MEXICO**
 - a. Energy Balance & Integration
 - b. Native Air
 - c. N-Demand Test and Balance LLC
 - d. Control & Equipment Company

1.5 SUBMITTALS

- A. Mechanical Contractor shall submit the name of the proposed TAB agency prior to the TAB agency performing any services.
 - 1. Submit a list of proposed personnel, including resumes with related project experience and certifications.
 - 2. Submit proposed TAB procedures, instrumentation and measurement equipment including calibration data, and proposed sample TAB report forms.
- B. Pre-Construction Report: Prior to the Mechanical Contractor installing the systems, the TAB Agency shall submit a letter indicating whether the design includes all devices the TAB Agency will need to successfully perform the TAB work. If any additional balancing devices are needed, the TABB Agency shall so note this in the pre-construction report.
- C. Submit TAB reports as noted herein. Reports shall be in both hard copy and PDF format.

1.6 TAB PREPARATION AND COORDINATION

- A. Mechanical Contractor shall perform the following in a timely fashion:
 - 1. Provide the TAB Agency with the project documentation (drawings, specifications, bulletins, submittals, shop drawings, etc.) necessary to perform the TAB services.
 - 2. Install, fill, pressure test, start up, clean, and the vent systems to be tested and balanced.

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- B. Controls Subcontractor shall perform the following in a timely fashion:
 - 1. Install and make operational all necessary control systems and equipment, including computers and computer programs.
 - 2. Provide qualified personnel to operate the systems as necessary to support the TAB effort. Provide the TAB contractor with the computer software necessary to facilitate the TAB effort.
 - 3. Assist as required to resolve problems which become evident due to TAB work, and as required to obtain specified system performance.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Provide all equipment and instruments necessary to perform the work specified herein. Calibrate and maintain instruments per NEBB Standards. Provide not less than the following:
 - 1. Pitot tubes and draft gauges.
 - 2. Flow hood.
 - 3. Velometer.
 - 4. Thermometers.
 - 5. Pressure gauges.
 - 6. Flow meter test kit.
 - 7. Ampere – voltmeter.
 - 8. Speed indicator.
 - 9. Sound meter to measure eight octave bands.

PART 3 - EXECUTION

3.1 GENERAL

- A. Review and inspect the mechanical systems for conformance with design documents. Test, adjust and balance all system flows under design conditions and under other conditions where part load testing is specified. Comply with measurement tolerances per NEBB. Balance to within 10% of design flows unless otherwise specified.
- B. Visually mark the final settings of balancing dampers, fan speed controls, etc.
- C. Comply with NEBB Standards. The descriptions included herein are a guide to the minimum information needed.
- D. Troubleshooting: In the event that any areas fail to get proper flow, take the lead in troubleshooting the system. Measure pressures, flows, etc. at various points throughout the systems as required to identify the cause of the deficiencies and identify upgrades which will resolve these deficiencies. Coordinate any remedial efforts directly with mechanical and controls contractors and re-test as required.

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3.2 TEST AND BALANCE REPORT

- A. Report shall be 8-1/2" x 11" bound into a complete and coherent report, except that drawings may be larger size, but still bound into the report. All forms shall be typewritten or legibly handwritten.
- B. Include the following sections in the order indicated:
 - 1. Cover sheet with the Project Name, Location, and the names of the Mechanical Contractor and Engineer
 - 2. Table of Contents
 - 3. Summary indicating the highlights of the report and summarizing any deficiencies and recommendations
 - 4. Test results including the names of the persons performing the tests and dates the tests were performed
 - 5. Drawings
 - 6. Description of the test procedures used
 - 7. List of instruments used along with their calibration data
 - 8. Qualifications of personnel
- C. Submit five copies and a PDF of the complete TAB report minimum two weeks before the first O&M instruction session. One copy will be returned to the Contractor with review comments.

3.3 BASIC AIR HANDLING SYSTEM TESTING, ADJUSTING AND BALANCING

- A. General
 - 1. Test all fans and air handling systems. Balance systems to achieve specified air flows while minimizing throttling losses.
 - 2. Air Flow Measurements: Fan and AHU flow rates may be determined by pitot tube traverse or by measuring fan speed, suction and discharge pressures, and comparison with the fan curve. Measure duct air flows using pitot tube traverses. Measure air flows of grilles, registers and diffusers using either capture hoods or pitot tube traverses in the connected ductwork. Make such other tests as may be required to demonstrate that systems perform per the design requirements.
 - 3. Air Flow Measuring Stations: Calibrate each air flow measuring station which is provided as part of the construction contract. Use duct pitot tube traverses or other appropriate means to measure air flows. Coordinate with the flow measuring station supplier, and enter calibration coefficients into the FMS. Record the results of this effort.
 - 4. Alert Mechanical Contractor and Engineer if any fan or air handling unit (AHU) appears to be operating in an improper or unsafe condition.
 - 5. Seal all test holes in ductwork once testing is complete. Repair insulation jackets to maintain the integrity of the vapor barrier.
 - 6. Include in the report copies of ductwork drawings with test points indicated.
 - 7. Variable Flow Systems: Verify proper fan tracking from full flow to 50% flow.
- B. Fans: Perform the following for all fans, including those provided as part of an AHU.
 - 1. Fan Nameplate: Record unit number per the equipment schedule, manufacturer, model, size, and serial number.
 - 2. Performance Data: Measure air flow and adjust fan speed to achieve required flow. Record air flow, static pressure rise and fan speed.

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- a. Advise when belt and/or sheave changes are required to achieve the design flows. Mechanical contractor shall make the necessary changes as part of the mechanical contract. Approximately 25% of fans may require a sheave and/or belt change.
 3. Current and Voltage: Record motor nameplate and measured voltage and amperage. Advise if motor amps exceed rated load amps.
- C. Air Handling Units:
1. Outside Air: Test outside air flows using a pitot tube traverse and balance as required. If a traverse is not practical, use the mixed air temperature method if the inside and outside temperature difference is at least 20 deg F, or use the difference between pitot tube traverses of the supply and return air ducts.
 2. Static Pressure: Measure and record the static pressure at the inlet and outlet of each AHU component, including louvers, dampers, filters, coils, etc, and at each inlet and discharge duct connection.
- D. Air Distribution Systems:
1. Zone, Branch and Main Ducts:
 - a. Adjust to within 10% of design air flows. Balance so that at least one zone balancing damper is wide open. Balance multi-diffuser branch ducts so that at least one outlet or inlet damper is wide open.
 2. Air Terminal Units:
 - a. Calibrate flow sensors and enter design maximum and minimum flow setpoints into FMS.
 - b. Record terminal unit number, size, specified flow, agency measured flow, FMS measured flow, and DDC flow correction factors.
 3. Diffusers, Registers and Grilles:
 - a. Test, adjust, and balance each diffuser, grille, and register to within 10% of specified design requirements. Record the size of each grille, diffuser, and register, initial flow measurement, and final measured flow.
 - b. Where rooms are indicated to be maintained at either positive or negative pressure, balance air flows to achieve these conditions under design flow conditions, and verify proper pressurization at minimum flow.
- E. Fan Coil Units, and other devices with fans and coils:
1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
 2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.
- F. Duct Leakage Testing
1. Specification Section 23 3000 describes the requirements for duct leakage testing. Provide all instrumentation and labor to take the required measurements.
 2. The Mechanical Contractor shall provide the fans and all other required work.
 3. Submit test report. Retest until ductwork complies with specified leakage criteria.

3.4 LIMIT DEVICES AND SAFETY CONTROLS

- A. Limit Devices: Check all limit devices to verify proper operation, including, freezestats, flow switches, etc. Include in the TAB report a list of all such devices and the results of their tests.

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- B. Fire and Smoke Dampers
 - 1. Test each fire damper, smoke damper, and fire/smoke damper to ensure proper operation. Record test results.
 - 2. Fire Dampers: Open access door, disconnect fusible link or activate thermal link, and verify that damper closes smoothly and completely. Reset damper and access door.
 - 3. Smoke Dampers: Open access door, activate damper, observe whether it closes smoothly and completely, and measure closing time. Reset damper and verify it opens completely. Close access door and record test results.

- C. Life Safety Controls: Test and record life safety control operation of the HVAC systems. Verify the installation of required smoke detectors in air handling equipment, and verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown or other required functions as described on the control drawings and sequence of operation. With assistance from the contractors for mechanical, temperature controls and electrical work, verify the operation of interconnected systems, such as the smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequence.

3.5 **SOUND TESTING**

- A. Measure sound level in approximately ten percent of rooms as directed by Engineer.
 - 1. Shut off mechanical equipment and measure background sound level in each octave band.
 - 2. Start mechanical equipment and measure sound level in each octave band.
 - 3. Submit a plot of measured data against noise criteria (NC) curves.

- B. Where measured sound levels are deemed by Owner to be unacceptable, work with Engineer and Mechanical Contractor to reduce actual levels, and retest as required.

3.6 **AIR HANDLING SYSTEMS – SPECIAL APPLICATIONS**

- A. Fume Hoods: Test exhaust airflow by duct pitot tube traverse, and adjust exhaust air valve to control to within 5% of design flow. Balance makeup air flows as specified above. Test for turbulence and proper air flow patterns at the face and inside hoods using a smoke puffer or other approved smoke-emitting device. Document the test results, and advise of any concerns and recommendations.

END OF SECTION

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SECTION 23 0700 – MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 3000, Air Tempering System and Equipment.

1.3 SCOPE

- A. Field insulation of piping: see drawings and Part 3 of this specification.
- B. Field insulation of ductwork: See drawings, Table 23 0700-1, and Part 3 of this specification.
- C. Field insulation of equipment supplied and/or installed under Division 23: See drawings and Part 3 of this specification.
- D. Factory-insulated equipment and materials are described on the equipment schedule, on the drawings, and in other sections of this specification.

1.4 SUBMITTALS

- A. Submit products to be used including insulation, jackets, miscellaneous products, and products for special applications. Review each application and advise if any product is either not suitable for, or not recommended for the application.
- B. Verify that each submitted product meets all requirements for that product as specified herein. Include literature that clearly shows products meet all aspects of the spec. Include a cover sheet or letter with the following statement:

“Each product submitted here meets all specified requirements for that product except as follows:” followed by a list of any discrepancies.

- C. Submit schedules showing the type of product and thickness for each application. Indicate products to be used on valves and fittings. Indicate where vapor barriers will be provided and what jackets will be used.
- D. D-5, D-6 & D-7 insulation: If one of these insulations is specified, submit documentation indicating that the submitted materials are approved for the intended service.

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- E. Submit a description of the application techniques to be used.

1.5 QUALITY ASSURANCE

- A. Comply with the latest edition of the National Commercial & Industrial Insulation Standards, as published by the Midwest Insulation Contractors Association.
- B. Part 3 and Table 23 0700-1 give the system temperatures for various applications. Supplier shall review these temperatures and confirm the suitability of all components for the specified applications.
- C. Test piping and ductwork in accordance with applicable specification sections before insulation is applied.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials must be 100% asbestos-free and 100% formaldehyde-free, NO EXCEPTION.
- B. All materials must be GreenGuard Gold Certified.
- C. Smoke and Fire Ratings: All materials shall have a composite fire and smoke hazard rating not exceeding flame spread 25, fuel contribution 50, smoke developed 50, when tested as assemblies per ASTM Standard E 84 or NFPA 255.
- D. Thermal conductivities: Per ASTM C518. Do not exceed the conductivities indicated. Units listed herein for conductivity are Btuh-in/SF-F. Resistance shall not be less than the values specified herein. Units for resistance are SF-F/Btuh.
- E. Noise Reduction Coefficients: Per ASTM C423 based on Type A mounting. NRC shall not be less than as specified.
- F. Jackets: Maximum 0.02 perm water vapor transmission per ASTM E96 Procedure A.
 - 1. ASJ: All service jacket per ASTM C1136 Type I, paintable white kraft paper outer surface reinforced with glass fiber yarn and bonded to aluminum foil, with self-sealing longitudinal lap and butt strips, breach puncture min. 50 oz-in/in tear per ASTM D781, tensile strength min. 30 lb/in per ASTM D828.
 - 2. FSK: Foil skim kraft per ASTM C1136 Type II.
- G. Fiberglass insulation: Inorganic fibers bonded with thermosetting resin.
- H. Approved Manufacturers: Owens Corning, Johns Manville, Knauf, Certain-Teed, Kflex, Armacell, Unifrax -Insulfrax, Industrial Insulation Group, Pittsburgh Corning. Where the term OAE is used herein, this refers to these manufacturers only. No other manufacturers are approved for this project.

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2.2 PIPE INSULATION

- A. General
1. Valves, Fittings, and Accessories: Use the same insulation materials and thickness as the pipe insulation, except as noted.
- B. Type P-1, Fiberglass Pipe Insulation: Factory assembled insulation and ASJ. Pre-formed fiberglass per ASTM C547 Type I, suitable for use on surfaces from 0–850oF, with thermal conductivity 0.23 at 75oF or 0.33 at 250oF, and minimum 3 pcf density. ASJ shall have self-sealing lap at end and along length, with pressure sensitive tape lap sealing system. Owens Corning SSL II Pipe Insulation, Johns Manville Micro-Lok, Knauf Pipe Insulation.
1. Where Type P-1 insulation is used, insulate fittings, valves and accessories using one of the following:
 - a. Fiberglass pre-formed fitting insulation complying with the specification for P-1 pipe insulation, Johns Manville Hi-Lo Temp insulation inserts, Hamfab, OAE. Finish with Type J-2 fitting covers.
 - b. Where pre-formed fitting insulation is not available, the following may be used: minimum 0.75 pcf density fiberglass per spec for D-1 insulation except without FSK. Finish with Type J-2 fitting covers or with two coats of fitting mastic with fiberglass fitting tape embedded between coats.
- C. Type P-2, Fiberglass Pipe and Tank Insulation: Similar to Type P-1 insulation and jacket, except with fibers oriented to allow insulation to be wrapped onto curved surfaces, with conductivity 0.30 at 100oF, or 0.55 at 400oF. Johns Manville Pipe & Tank Insulation, Owens Corning Pipe and Tank Insulation or Knauf Pipe and Tank Insulation.
1. Alternate: Fiberglass board insulation similar to Type D2, scored for application on curved surfaces, with ASJ.
- D. Type P-3, Calcium Silicate Pipe Insulation: Rigid calcium silicate per ASTM C533, Type 1, asbestos-free, suitable for use on piping up to 1200oF, conductivity 0.55 at 700oF, compressive strength min. 200 psi at 5% compression. Industrial Insulation Group OAE.
1. Fittings, valves and accessories: Insulate with mitered Type P-3 insulation or Type D-7 insulation.
- E. Type P-4, Elastomeric Foam Pipe Insulation: Pre-formed elastomeric foam, ASTM C534 Type 1 flexible, closed cell, suitable for use up to 220oF, UV protected, not to exceed flame spread 25 and smoke developed 50 based on 0.75-inch thickness, conductivity 0.30 at 75oF. Kflex, Armacell OAE.
1. Fittings, valves and accessories: Insulate using either Type P-4 insulation pre-formed for use on fittings and valves, or cut sections of P-4 pipe insulation to match the shape of the fitting or valve, taped on using PVC tape.

2.3 DUCTWORK INSULATION

- A. Type D-1, Fiberglass Blanket: Factory fabricated insulation and FSK jacket assembly suitable for applications from 40-250oF, 3/4 pcf fiberglass, ASTM C553 Type I or II, with thermal resistance not less than the following for 2-inch thickness: 6.8 out of the box, 5.6 installed with 25% compression. Johns Manville Microlite XG Duct Wrap, Owens Corning Soft R Duct Wrap, Knauf Friendly Feel Duct Wrap, Certainteed Soft Touch Duct Wrap.

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- B. Type D-2, Fiberglass Board: Similar to Type D-1 except rigid board type, 3 pcf density, thermal conductivity 0.23 at 75oF, NRC 1.36, suitable for unfaced side at up to 450oF and faced side at up to 150oF. Johns Manville 800 Series Spin Glas, Owens Corning 700 Series Board, Knauf Insulation Board, Certainteed Certra Pro Commercial Board
- C. Type D-3, Acoustic Lining (roll type): Organic fiber or fiberglass duct liner bonded with thermosetting resin, with factory-applied acrylic surface coating treated with anti-microbial agent, and factory-applied or shop-applied edge coating.
 - 1. Properties: Minimum 1.5 pcf density, thermal conductivity 0.24, 6000 FPM rated per UL 181, NRC 0.70 at 1-inch thick and .95 at 2-inch thick. The product (fiberglass, resin, coating, microbial agent and adhesive) as an assembly shall be suitable for surfaces and gases up to 250oF, and shall comply with ASTM C1071 (Type I), G21 and G22.
 - 2. Lining surface shall be cleanable using commercially available duct cleaning equipment when performed by qualified technicians using procedures established and recommended by the North American Insulation Manufacturer's Association (NAIMA) Duct Cleaning Guide.
 - 3. Johns Manville Linacoustic RC, Owens Corning Acoustic R duct liner, Knauf EM duct liner, Certainteed ToughGuard R Duct Liner.
- D. Type D-4, Acoustic Lining (board type): Similar to Type D-3 and complying with all aspects of the spec for Type D-3 insulation, except 3 pcf density rigid board with NRC 0.75 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Permacote Linacoustic R-300. Owens Corning Duct Liner Board, Knauf Rigid Plenum Liner, Certainteed Rigid Liner Board.
- E. Type D-5, Grease Duct Applications: High temperature, foil-encapsulated inorganic blanket, 8 pcf. Insulfrax Fyre Wrap Max 2.0, Johns Manville Fire Temp, OAE. Product shall meet the following when applied as 2-layers around a grease-duct:
 - 1. Tested and listed for zero clearance to combustibles across the entire surface of the blanket material per internal fire test AC101 or ASTM E2336 - Internal Fire Test – 2 Hr Grease Duct Enclosures.
 - 2. Rated as a 2-hr fire resistive enclosure assembly per ASTM E-119, Engulfment Fire Test for 2-hr Grease Duct Enclosure.
- F. Type D-6 –Combustible Materials within Plenum: For use on combustible materials located within supply or return air plenums, foil-encapsulated 8 pcf high-temperature ceramic fiber blanket suitable for service up to 1800oF. Unifrax Fyre-Wrap 0.5 plenum insulation.
- G. Type D-7 – Fire Rated Ductwork: Suitable for continuous operation at 1800oF, 6-pcf, foil-encapsulated inorganic blanket to provide a 2-hour rating per ISO 6944 when applied in a single 1.5-inch thick layer. Insulfrax FyreWrap 1.5 OAE.
- H. Type D-8 – Polystyrene Insulation: Rigid cellular square edge insulation per ASTM C578, waterproof, thermal conductivity 0.20, compressive strength 25 psi. Dow Styrofoam or Owens Corning Foamular.
- I. Type D-9 – Fiberglass Ductboard: Listed per UL 181 as a Class 1 Rigid Air Duct; conforming to ASHRAE Std. 62, NFPA-90A and 90B, ASTM G-21 & G-22; rated for 2-in. wg; constructed of fiberglass bonded with a thermosetting resin, with double density slip joints pre-molded in the board; FSK jacket; thermosetting acrylic polymer interior surface, and black interior surface color. Thermal conductivity 0.23, and NRC 0.70 at 1-inch thick and 1.0 at 2-inch thick. Johns

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Manville Superduct 475 or 800, Owens Corning Quiet R Duct Board, Knauf Duct Board M, Certainteed ToughGard Duct Board

2.4 INSULATION JACKETS

- A. Type J-1, Metal Jacket: 0.010 inch smooth Type 304 stainless steel or 0.016 inch smooth or embossed aluminum per ASTM B-209, with minimum 1-mil polyethylene film with protective layer of 40 Lb virgin kraft paper, continuously laminated to full width inside jacket. Childers OAE.
 - 1. Where jacket diameter is 16–96 in: 0.016-in. SS or 0.020 in. aluminum.
 - 2. Equipment heads and all surfaces where jacket is greater than 96-inch OD: 0.020-inch SS or 0.024 inch aluminum.
 - 3. Fittings and Accessories: Provide the same jacket material as for pipe.
- B. Type J-2, PVC Jacket: Minimum 20 mil sheets and 30-mil pre-molded fitting covers, ASTM D1784, Class 16354-C. Accessories include solvent weld solution, stainless steel tacks, and tape. All components shall be white, UV resistant, with paintable exterior surface, and suitable for use at –20 to +150oF. Johns Manville System 2000 (sheets), Zeston 300 (fitting covers), and Perma-Weld (solvent cement), OAE.
- C. Type J-3, Canvas Jacket: 10 x 10 fiberglass mesh.

2.5 MISCELLANEOUS PRODUCTS

- A. General:
 - 1. Tapes: Aluminum, pressure sensitive, UL 181A-P listed and embossed, minimum 2.5-inch wide, Nashua 324A OAE.
 - 2. Duct Liner Adhesives: Water-based, complying with ASTM C916.
 - 3. Solvent Cement for PVC Jackets: Johns Manville Perma-Weld OAE.
 - 4. Staples: Outward clinching, 0.5-inch galvanized steel
- B. Piping Systems:
 - 1. Pipe Hanger Insulation Inserts: Mechanical Pipe Shields Inc. “Snapp Itz” OAE.
- C. Ductwork Systems:
 - 1. Duct Liner Edge Sealer, Surface Sealer, Coatings & Adhesives: To meet ASTM C916. Johns Manville Superseal OAE.

PART 3 - EXECUTION

3.1 GENERAL

- A. Delivery, Storage and Handling: Deliver and store insulation materials in factory-supplied containers. Protect from moisture. Do not install any materials that have gotten wet, regardless whether they are subsequently dried.

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- B. Store and apply materials in accordance with manufacturers' recommendations, but not less than the following minimum temperatures. Ensure surfaces are clean and dry prior to application, and for minimum two hours after application:
 - 1. Sealers, coatings, solvents and adhesives: 40oF.
 - 2. Tapes 50oF.
- C. Install in accordance with manufacturer's recommendations, NAIMA recommendations, and this spec. Provide good ventilation.
- D. Where vapor barriers are specified, ensure that the entire system is vapor sealed.
- E. Protect materials from water damage. Replace any materials that are water-damaged prior to substantial completion.

3.2 **PIPING INSULATION**

- A. General: Insulate piping as indicated herein and/or on the drawings. Except as noted, insulate all valves, fittings, and accessories with the same material and thickness specified for the pipe. Where piping is specified with a separate insulation jacket provide this same jacket for valves, fittings and accessories. Vapor seal cold piping systems.
 - 1. Where insulation terminates, provide insulating cement beveled for a neat finish. For vaporsealed piping, coat with insulating mastic prior to applying insulating cement.
 - 2. Strainers and Suction Diffusers: Either Type P-1 or P-3 insulation. Make provisions to easily remove and re-install insulation.
 - 3. Pipe Supports: Provide high density calcium silicate insulation or insulation inserts as specified. Maintain pipe jacket and vapor barrier at supports. If necessary, apply a heavy coating of vapor barrier mastic material to prevent condensation from forming on supports. Provide galvanized steel insulation shields to protect insulation and jackets at supports.
 - 4. Penetrations Through Building Construction: Insulation shall be continuous where piping passes through walls, floors, and other construction. Where insulated piping passes through fire and/or smoke rated construction, provide a section of UL approved fire safing insulation to match the required insulation thickness, or provide an insulated pipe sleeve as manufactured by Pipe Shield, Inc., OAE.
 - 5. Mechanical Couplings: Where mechanical couplings are permitted, insulate them as specified for fittings.
 - 6. Steam Traps: Do not insulate.
 - 7. Retrofit Projects: Match the thickness of existing insulation where new insulation adjoins existing. Integrate new vapor barrier with existing so the insulation barrier is continuous for both new and existing piping.
 - 8. **[All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.]**

- B. Application:

Temp Range	Temp (F)	Insulation Type	Vapor Sealed	Pipe Size				
				< 1	1 to 1-1/4	1.5 to 3	4 & 6	≥ 8
TR-1	< 40	P-1 or P-4	Yes	0.5	1.0	1.0	1.0	1.5
TR-2	40-60	P-1 or P-4	Yes	0.5	0.5	1.0	1.0	1.0
TR-3	61 – 104	P-1	Yes	0.5	0.5	0.5	0.5	0.5

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1. Temperature Range TR-1: Chilled water (Glycol)
 2. Temperature Range TR-2: **Refrigerant suction, condenser water (outdoor piping subject to freezing).**
 3. Temperature Range TR-3: **Condensate drains indoors.**
- C. Special Applications
1. Handicap Lavatories: Insulate domestic hot and cold water piping and P traps exposed below handicapped lavatories with insulation kit specifically designed for the application.
- D. Type P-1 & P-2, Fiberglass Insulation: Install in accordance with manufacturer's recommendations.
- E. Type P-3, Calcium Silicate Insulation: Adhere to pipe or equipment using stainless steel wire. Provide removable J-1 jacket.
- F. Type P-4, Elastomeric Foam: Seal all butt ends and longitudinal joints with Halstead Adhesive. When exposed to the weather, protect flexible tubing insulation with two coats of exterior weatherproof coating as recommended by manufacturer.
- G. Jacketing: In addition to the finish and jacket specified for the particular type of insulation, provide the following:
1. Indoor piping exposed to physical damage Type J-2, PVC
 2. Mechanical Eqpt Spaces: Exposed piping less than 8 ft above floor or operator platform Type J-2, PVC

3.3 DUCTWORK INSULATION

- A. General:
1. Insulate all ducts except those specified to be uninsulated. The following ductwork need not be field insulated:
 - a. **Factory insulated ductwork and plenums.**
 - b. **Ducts with acoustic lining, provided the lining thickness matches or exceeds the required insulation thickness.**
 - c. **Exhaust ducts, except where noted.**
 2. See Table 23 0700-1 for additional information.
 3. Ensure that ductwork is leakage tested prior to applying insulation. Inspect ductwork and repair any deficiencies prior to applying insulation. Do not apply insulation over deficient ductwork or plenum construction.
 4. Ensure that ductwork is clean and dry before applying insulation.
 5. For ductwork with acoustic lining the drawings indicate the "clear inside duct dimension" required. Over-size ducts as required to provide the required air flow area.
- B. Type D-1, Fiberglass Blanket Insulation: Measure and cut insulation. Install so insulation is not excessively compressed at corners. For rectangular and flat oval ducts 24-inches and wider, provide stick pins and speed clip washers 18-inches on centers on the bottom, and clip off excess length of stick. Firmly butt insulation ends and longitudinal joints. Overlap jacket minimum 2-inches at end joints and longitudinal joints, staple on 6-inch centers, and continuously seal jacket. Provide vapor barrier mastic where ducts are indicated to be vaporsealed. Should gaps or fishmouths occur, re staple and seal them with mastic. Use FSK tape and vapor barrier mastic to

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seal all penetrations of the FSK jacket, such as pins, tears, and hangers. Neatly trim and seal insulation at access doors, ends, damper rod controls etc. Verify proper damper operation.

- C. Type D-2, Fiberglass Board Insulation: Attach with mechanical fasteners 12" on centers.
- D. Type D-3 & D4, Acoustic Lining: Ductwork dimensions indicated on the drawings are net air flow dimensions inside liner. Increase duct size to accommodate liner. Completely line the inside surfaces of ducts and plenums specified and indicated. Comply with the NAIMA Fibrous Glass Duct Liner Standard (FGDLS), manufacturer's recommendations, and this spec. Adhere liner with minimum 90% coverage of adhesive, and secure with mechanical fasteners and washers per FGDLS and manufacturer's recommendations. Fastener length shall be sufficient to limit compression of liner to 1/8" maximum. Coat all cut edges and surface penetrations with edge sealer. Provide metal nosing for liner leading edges at fan discharge and for all ducts with air velocities exceeding 3,000 FPM. Maintain minimum 18-inch clearance from electric resistance heaters. Interrupt liner at dampers and apply external insulation at these locations.
 - 1. Provide Type D-3 insulation for the 10 feet upstream of roof exhaust fans except in wet air streams.
- E. Type D-5: Install insulation in a 2-layer system per manufacturer's instructions, including the use of mechanical fasteners for the underside of ducts, butting or overlapping of joints, and offsetting of joints on outer layer.
- F. Type D-6: Install in accordance with manufacturer's instructions. Overlap seams and joints minimum 2-inches, affix with SS wire minimum 18-inches on centers, but not less than per manufacturer's recommendations, and tape seams and joints with aluminum tape.
- G. Type D-7: Install insulation in a single-layer system per manufacturer's instructions. Mechanical fasteners for the underside of ducts shall be adhered to the duct in a manner suitable for the operating temperatures (welded or other suitable method). Butt or overlap joints per manufacturer's recommendations.
- H. Type D-8: Wire in place with SS wire minimum 12-inches on centers, and provide J-1 jacket.
- I. Type D-9: Install per manufacturer's recommendations, NAIMA standards, and SMACNA Fibrous Glass Duct Construction Standards. Provide ship lap seams and joints.

END OF SECTION

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Service	Location	Condition	Insulation Type	Insulation Thickness (in)	Notes
Supply Air, Makeup Air, Outside Air	Indoor	Concealed	D1	2.0	1, 6
Supply Air, Makeup Air, Outside Air	Indoor	Exposed	D2	2.0	
Supply Air, Makeup Air, Return Air	Outdoor	All	D8	2.0	2, 4, 7
Supply Rectangular Ductwork downstream of Terminal Units, Fan Coil Units, Heat Pumps, Blower Coils and Low Velocity AHU's	Indoor	All	D1	2.0	1, 3
Return Rectangular Ductwork upstream of Fan Coil Units, Heat Pumps, Blower Coils and Low Velocity AHU's	Indoor	All	D1	1.5	3
Ductwork indicated to be lined	All	All	D3	1	5
Ductwork indicated to be lined with 2-inch acoustic lining	All	All	D3 or D4	2	5
Single Wall Lined Plenums	All	All	D4	2	
Transfer Air Ducts	All	All	D3 or D9	1	
Exhaust Ductwork	Indoor	Concealed	D1	1.5	8
Exhaust Ductwork	Indoor	Exposed	D2	1.5	8
Kitchen Exhaust Ductwork	Indoor	All	D5	2-layers	
Plastic Piping and Ductwork within RA Plenums	Indoor	Concealed	D6	0.5	
Fire-Rated Ductwork Other than Kitchen Exh	Indoor	All	D7	1.5	
Boiler Breeching & Stack	Indoor	All	P1 or P2	3	
Boiler Breeching & Stack	Outdoor	Exposed	P1 or P2	3	4, 7

Notes:

1. Includes Supply Air Duct from Energy Recovery Units and Evaporative Coolers.
2. Provide acoustical liner as indicated on the drawings.
3. In general, insulation is not required on return ductwork if located in an indirectly conditioned space such as a ceiling plenum space. Provide type D3 insulation in duct if indicated to be lined on the plans or installation details.
4. Provide J1 Jacket.
5. In hospitals do not provide acoustical lining in supply ductwork or plenums downstream of the final filter.
6. Vaporseal ducts conveying cold air.
7. Seal outdoor ductwork to prevent ingress of moisture.
8. Insulate only the portion of exhaust ductwork between isolation damper and outside.

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SECTION 23 2313- REFRIGERANT PIPING SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform to the applicable provisions of the General Conditions, the Supplemental General Conditions and the General Requirements.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0700, HVAC Insulation.
- C. Division 25, Integrated Automation for temperature control valves, meters and instrumentation.
- D. Division 26, Electrical.

1.3 QUALIFICATION PROCEDURES

- A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements. In no situation shall any refrigerant be discharged to the atmosphere. All refrigerants recovered from all systems shall be disposed of in compliance with these same regulations.

PART 2 - PRODUCTS

2.1 FAN COIL UNITS

- A. **Fan Coil Units** shall be as specified on the Equipment Schedule on the drawings and Section 23 3000.

2.2 AIR COOLED CONDENSER

- A. Furnish and install air cooled condensers located on building roof as shown on the drawings. Air cooled condenser shall be of type and capacity as specified in the Mechanical Equipment Schedule on the drawings.

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2.3 PIPING

- A. Refrigerant piping materials and installation shall be in accordance with the best working and piping practices for Freon refrigerants. The Contractor shall install the refrigerant piping using Type "L" hard drawn copper tubing, Federal Specification WW-T-749, with silver solder joint. All piping shall be installed in a straight manner, free from traps, and shall be provided with plugged or capped ends, as it is erected, to prevent dirt from entering. The piping system shall be provided with gauges as required for the operation of the system. The piping is shown schematically on the drawings, verify exact arrangement and pipe sizing with equipment manufacturer.

2.4 VALVES

- A. Expansion valves shall be of the thermostatic type as manufactured by Alco, Sporlan, or equivalent, and shall be gas charged with capillary tube, external superheat adjustment and external equalizing connection. The expansion valves at each apparatus shall be protected by a strainer in the refrigerant liquid line to that group. The strainer shall be as manufactured by the Henry Valve Company, or equivalent, not less than line size and provided with shut-off valves before and after, and furnished with the packaged reciprocating unit.
- B. Solenoid valves shall be suitable for the system in which they are used and shall be designed specifically for use with Freon refrigerants. Solenoid valves shall be furnished with the packaged reciprocating unit.
- C. Refrigerant line valves shall be packless type or packed type with gas tight cap seal with wheel, globe, angle, or "T" needle type, with hard metal seats and shoulders on stems to permit packing stuffing boxes while open under pressure, or sealed diaphragm type.

2.5 DRYER

- A. In each liquid line, install a suitable silica gel filter and dryer. Dryer shall be furnished with the chiller.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Piping installation shall conform to the requirements of Section 23 0500, Common Requirements for HVAC, and Section 23 0504, Pipe and Pipe Fittings.

3.2 TESTING OF REFRIGERANT PIPING SYSTEM

- A. After the installation of the refrigerant piping system has been completed, all piping shall be tested and proven tight for a period of [twenty four (24)] hours at a pressure of 150 lbs. per square inch using dry nitrogen.

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3.3 EVACUATION AND CHARGING

- A. Upon completion of the piping pressure test, the refrigerant circuit shall be evacuated to 500 microns using a closed tube manometer and a high vacuum pump (using an electronic vacuum gauge that reads in microns) to ensure tightness of the piping and to remove air and moisture from the piping system. Upon completion of evacuation and acceptance of the system tightness, the vacuum shall be broken by the introduction of the refrigerant.

3.4 REFRIGERANT AND LUBRICATING OIL

- A. Contractor shall furnish and install all of the refrigerant required to develop the system to its full rating, and in addition to the initial charge, the Contractor shall be required to provide all refrigerant required for the proper operation of the refrigeration apparatus during the first season's operation. Contractor shall guarantee that the loss of refrigerant for a season's operation shall not exceed 10% of the full charge of the system and he shall furnish any refrigerant required above this amount. This guarantee shall remain in effect until such time as the Contractor shall demonstrate this performance for one full year's operation. The Contractor shall be required to provide the initial charge of lubricating oil for all refrigeration apparatus and related equipment, and shall furnish a chart listing the type of oil and a schedule for maintenance that should be used with the various equipment.

3.5 PRESSURE RELIEF DEVICES

- A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15-1994. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.
- B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

END OF SECTION

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SECTION 23 3000- AIR TEMPERING SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Provide all products, labor and services necessary to construct and demonstrate proper functionality of the HVAC and exhaust systems indicated on the drawings and specified herein.
- B. Conform with applicable provisions of the General Conditions, the Supplemental General Conditions and General Requirements.
- C. See Sections 23 0500, 23 0548, 23 0549, 23 0593, and 23 0700, for additional requirements.
- D. Comply with the Equipment General Requirements in Spec Section 23 0500.

1.2 SCOPE

- A. Install control dampers supplied under Division 25. Adjust dampers for smooth operation.
- B. Equipment provided by others: Provide ductwork to serve equipment provided by others, including **fume hoods**, etc, where that equipment requires ducted supply or exhaust.

1.3 SUBMITTALS

- A. Submit the following for review and approval:
 - 1. All equipment shown on the equipment schedule and elsewhere on the drawings. Submit evidence or certification that equipment complies with ASHRAE Std. 90.1.
 - 2. Ductwork construction standards, sheet metal, plenums, ductwork accessories, etc.
 - 3. Dampers for fire and smoke control: For each type of damper proposed, submit manufacturer's literature demonstrating compliance with all aspects of the specifications and drawings. Submit manufacturer's installation instructions.
 - 4. Air Filters and Filter Gauges
 - 5. Grilles, Registers & Diffusers: Configuration, materials of construction, finish, mounting details, and performance data including throw, static-pressure drop, and noise ratings. Submit for type only, but supplier shall check and verify that the indicated diffuser type and sizing are appropriate for each area. Advise of any concerns in any areas.
 - 6. Terminal Units:
 - a. Submit the following for each type of unit: Unit construction, materials, and wiring diagrams.
 - b. Submit the following for each size unit: Dimensional data, recommended flow ranges, and performance data (pressure drop and sound data) at maximum flow.
 - c. Submit a schedule showing the following for each terminal unit indicated on the drawings: Tag number, max & min CFM, size, pressure drop, and heating system performance.

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1.4 QUALITY ASSURANCE

- A. Comply with the following codes & standards:
 - 1. UMC 2021 Chapter 6 – Duct Systems
 - 2. UMC 2006 Standard 6-2, Standard for Metal Ducts
 - 3. SMACNA 2005 HVAC Duct Construction Standards – Metal and Flexible, including Addendums
 - 4. SMACNA Round Industrial Duct Construction Standards – 1999
 - 5. SMACNA Rectangular Industrial Duct Construction Standards – 2004
 - 6. NFPA-90A-2002 - Standard for the Installation of Air-Conditioning and Ventilating Systems

- B. Component Characteristics
 - 1. All components within ducts and plenums shall be non-combustible or shall have a flame spread less than 25 and smoke developed less than 50 when tested as a composite product per NFPA 255, ASTM E84, or UL 723, except where specifically permitted by the UMC and noted in the drawings or specs.

1.5 SOUND LEVELS

- A. Sound levels attributable to mechanical equipment are designed to result in sound levels of NC 40 for **offices, conference rooms**, and NC 35 for **classrooms**, etc., measured within the rooms. Mechanical equipment that has been substituted for the specified equipment shall perform within the specified equipment sound limitations, or will be replaced or adjusted as required. Sound levels attributable to duct vibration that result in noticeable noise or vibration to duct hangers, lighting fixtures, ceiling tees or diffusers shall be re supported or adjusted until the disturbing noise is brought within acceptable limits.

1.6 DIMENSIONS

- A. Compare all drawings and verify all dimensions both on the drawings and in the field before laying out, cutting, and fabricating the work.

- B. Refer to Section 23 0500, Common Work Requirements for HVAC, for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 DUCTWORK AND PLENUMS

- A. Materials: Construct all ducts, casings, plenums etc. from galvanized steel sheets except as indicated. Sheets shall be free of blisters, slivers, pits, and imperfectly galvanized spots. Reinforcing angles and bars, and duct support materials shall be same material as ductwork if exposed to the air stream, or galvanized steel if not exposed to the air stream.
 - 1. Galvanized Steel: Per ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coat (Galvanized) by the Hot Dip Process G90 coating designation.
 - 2. Aluminum: Alloy 3003-H14

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3. Stainless Steel: 304SS, provide No. 2B finish in exposed areas
 4. Fiberglass Ductwork (Ductboard): Use only where specifically noted. Minimum 1-inch thick, 3 lb. density rigid fiberglass ductboard with glass fiber reinforced vapor barrier, UL Class 1, labeled on each board per UMC-06 Standard 6-5.
 - a. Properties:
 - 1) Thermal conductivity for 1-inch thickness shall not exceed 0.22 Btuh/SF-F at 75 deg F
 - 2) Noise reduction coefficient of 0.80 on Mounting No. 6.
 - b. Tape: 3 inch "Hardcast" mineral impregnated woven fiber tape with an actuator/adhesive applied in accordance with the manufacturer's directions, or thermlok heat sensitive tapes. Pressure sensitive tapes will not be accepted.
 - c. Owens Corning Fiberglass, Johns Manville, Certain Teed or equivalent. Flexural rigidity (E.I.) average shall not be less than 475.
 5. Polyvinyl Coated Galvanized Steel: Minimum 4 mil polyvinyl coating. Foremost Manufacturing Company, Southfield, Michigan. Model PCD 4 by 1 for exterior coating only, or Model PCD 4 by 4 for both interior and exterior coating.
- B. Flexible Ducts: Factory fabricated, listed as a Class 1 Air Duct per UL 181 with aluminum foil interior liner, corrosion resistant helix mechanically locked to fabric to ensure dimensional stability, helix separated from air stream, R-6 fiberglass insulation, and metalized outer vapor barrier. Ducts shall be rated at 10-inch positive pressure, 5-inch negative pressure, 0.1 perm per ASTM E96, and -20 to +250oF. Flexmaster Type 3M, Thermaflex M-KC, OAE.
- C. Ductwork Accessories
1. Sealers: Water based, for use on galvanized steel and with the other materials specified herein, suitable for use at -20 to +200oF and duct pressures to 10 inches wg, dry to the touch within 12 hours, sufficiently flexible to pass a 0.25-inch mandrel test, listed per UL-181A & 181B, and suitable for storage and application at 40–110oF. Approved Manufacturers: Carlisle Coatings & Waterproofing "Hardcast," Foster, RCD, AM Conservation Group, OAE.
 2. Tapes: 4" woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal. Water, mold, and mildew resistant for indoor and outdoor service. Sealant shall be modified styrene acrylic.

2.2 SHEET METAL ACCESSORIES

- A. Dampers: Factory fabricated, suitable for use with air at -20 to +240oF, galvanized steel housing and blades except as noted, rated for indicated pressures in either direction and performance rated per AMCA-500.
1. Shafts: Square or hexagonal steel, 3/8-inch or 1/2-inch, continuous through damper, mechanically fastened to damper blade, and extending through frame as required for actuator or standoff bracket and locking quadrant as required by table below.
 2. Bearings: Provide for each side of each shaft, molded synthetic or stainless steel sleeve type.
 3. Multi-blade dampers: Except as indicated, provide parallel-blade for 2-position applications and opposed blade for modulating applications. Provide jackshafts as required to drive large dampers.
 4. Air pressure drop shall not exceed:
 - a. Dampers rated at 1500 FPM: 0.1 in wg at 1500 FPM

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- b. Dampers rated at 4000 FPM: 0.25 in. wg at 4000 FPM
5. The dampers described in this section are assigned Type Numbers D1 through D23. The following table summarizes key characteristics of each type of damper. Drawings and Part 3 – Execution, indicate which type of damper to use in each application.

Type	Shape	Blade	Max Size (inches)	Multiple Sections	Rated Velocity (FPM)	Rated Shutoff Press. (in. wg)	Seals	Leakage (CFM/SF @ 1 in. DP)	Notes	Ruskin Model
D1	Rect	Flat	36 x 12	No	1500	2.5	No	--	1	MD15
D1	Rect	3V	48 x 48	No	1500	2.5	No	--	1	MD15
D2	Rect	Flat	36 x 12	No	1500	2	No	--	1	MD25
D3	Rect	3V	48 x 48	Yes	1500	2	No	80	1	MD35
D4	Rect	3V	48 x 72	Yes	1500	2.5	No	40		CD35
D5	Rect	3V	48 x 72	Yes	1500	2.5	Yes	4		CD36
D6	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2	2	CD50
D7	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2		CD60
D20	Round	Flat	20	No	1500	2	No	40	1	MDSR25
D21	Round	Double	40	No	4000	10	Yes	4		CDR25
D22	Round	Double	24	No	4000	6	Yes	6		CDSR25
D23	Oval	Double	72 x 24	No	4000	10	Yes	4		CDO25

Note 1: Provide locking hand quadrant and 2-inch standoff bracket

Note 2: Aluminum Construction

- B. Flexible Connectors: Except as noted flexible connectors shall be heavy fiberglass cloth; coated to be air tight, water tight, fire retardant; suitable for temperatures of -20 to +200o F; rated for 10 in. wg positive or negative; with tensile strength minimum 450 lb/inch in the warp and 340 lb/inch in the filling. Provide flexible connectors in 3-3-3 configuration, with 3-inch galvanized steel strip along each edge and 3-inches of flexible fabric in the center.
1. Standard Applications: Flame spread 20, smoke developed 40, Ventfabrics Ventglas OAE
 2. Applications Exposed to Sun and Weather: Double coated with du Pont Hyphalon, Ventfabrics Ventlon OAE.
 3. Applications from 200 – 500o F: Tensile Strength 285 lb/inch in the wrap and 185 lb/inch in the filling. Ventfabrics Ventsil OAE
 4. Corrosive Applications: Teflon coated, Ventfabrics Ventel OAE.
- C. Duct and Plenum Access Doors: Galvanized steel, gasketed. Size as required to properly inspect and service components located within the ductwork. Ruskin, Acudoor, Ductmate, OAE.
1. Rectangular ducts up to 2-inch positive or negative SP: Minimum 22 gauge frame and door thru 12-inch size, 20 gauge door for larger sizes, double gasketed (between door and frame, and between frame and duct) with cam locks, either hinged or removable. Ruskin ADH22, ADC22, ADHW22, or ADCW22, Ventfabrics, OAE
 2. Round or Rectangular Ducts to 12-inch Positive Pressure: Removable oval sandwich style with gasketed inner door, insulated outer door, and large hand knobs. Ruskin ADR and ADF.
 3. Ducts to 12-inch Negative Pressure: Ruskin ADHP-3.

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4. Plenum Access Doors: Factory fabricated frame and door rated to 4-inch positive or 8-inch negative pressure. Provide mill finish and neoprene seals to limit leakage to less than 0.1 CFM/inch perimeter with door closed. Doors shall open against air pressure.
 - a. Frame: Extruded aluminum with 1.5-inch flange and mitered corners
 - b. Door: Extruded aluminum mitered frame, double wall 24-gauge galvanized steel panel with minimum R-5 insulation isolated from the air stream, full-length piano hinge and two heavy-duty latches similar to Ventlok 310.
 - c. Approved Manufacturers: Ruskin GPAD or approved equal.

- D. Turning Vanes:
 1. Single wall: Per SMACNA HVAC Duct Construction Standards Figure 2-3 & 2-4.
 2. Double wall: Airfoil shape with smoothly rounded entry nose and extended trailing edge, minimum 2" x 3" vane cross-section, hot dipped galvanized steel, 26-gauge vanes, 24-gauge runner, each vane double pinned to each runner, field adjustable to required elbow aspect ratio. Performance shall not exceed the following for a 24 x 24 elbow at 2000 FPM average: Air pressure drop 0.105 in. wg; sound generated 54 dB re 10⁻¹² watts. Aero/Dyne Co. Model HEP, Airsan, Elgen, or equivalent.

- E. Roof Curbs and Equipment Support Rails: Factory fabricated, minimum 18-inch high, galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction.
 1. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, OAE.
 2. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck OAE

- F. Louvers: 4-inch extruded 6063-T5 aluminum alloy frame and blades with flange, mill finish, and 1/2-inch galvanized steel bird screen.
 1. Structural: Designed and furnished to carry wind load of not less than 20 psf. Intermediate mullions and supports if provided as part of louver, shall not be visible from the exterior.
 2. Air Pressure Drop: Less than 0.20 in wg at 1000 FPM over free area (8.58 square feet), intake or exhaust per AMCA 500 based on 48 x 48 test sample.
 3. Moisture Penetration: Less than 0.01 oz/sf over 15 minute test per AMCA-500 at 873 FPM intake over free area based on 48 x 48 test sample.
 4. Ruskin ELF375DX OAE.
 - 5.

- G. Thermometers: As specified in Section 23 0505.

- H. Barometric Pressure Balance Dampers: Air Balance, Inc. units with adjustable counter weight, aluminum air foil design blades, nylon bearings. Match frame assembly to wall or duct.

2.3 DAMPERS FOR FIRE AND SMOKE CONTROL

- A. General: Factory assembled and UL listed as an assembly, suitable for horizontal or vertical air flow and for ducted or un-ducted applications. Fire dampers (FDs) shall be listed per UL 555, smoke dampers (SMDs) shall be listed per UL 555S, and fire/smoke dampers (FSDs) shall be listed per UL 555 and UL 555S. Units shall be galvanized steel except as noted. Approved manufacturers: Greenheck, Ruskin, Potorff, or approved equal.

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B. Combination Fire/Smoke Dampers: Factory assembled complete with damper, actuator, thermal link, and all specified accessories, all mounted on a sleeve.

1. Construction: Round blades, rectangular parallel blades and rectangular opposed blades are acceptable, except dampers shall be rectangular opposed blade type when installed in any of the following conditions: within 10 diameters of a fan or supply register, within 3 diameters of an elbow. Internal frames in rectangular FSDs shall be low profile type for ducts 17"H and less.
2. All components factory installed and wired, including actuator, thermal link, position switches, temperature over-ride (if specified), test switch (if specified), etc. Mount all such components on outside of FSD sleeve to the side of duct (not top or bottom) except where indicated or approved. FSDs must be suitable for rotating the unit 180-degrees so these components can be on either side of the duct.
3. Air pressure drops shall be certified per AMCA 500D. Pressure loss coefficient Co shall not exceed the following when tested per AMCA Figure 5.3:

<u>Size (in)</u>	<u>3-V Blade</u>	<u>Airfoil Blade</u>	<u>Round</u>
12 x 12	2.41	2.01	NA
24 x 24	0.65	0.60	NA
36 x 36	0.44	0.27	NA
12 x 48	0.76	0.91	NA
12 Round	NA	NA	0.33
24 Round	NA	NA	0.23

4. Listed for installation within wall, floor or ceiling assemblies as indicated on drawings.
 - a. Ratings, except as noted: 1.5-hr Fire Rated, Leakage Class 1, 350oF, 4-inch Static Pressure, Dynamic.
 - 1) Up to 1600 FPM: Greenheck FSD-211 (3-V blade type), OFSD-211, or FSDR-511 (round).
 - 2) Up to 3000 FPM: Greenheck FSD-311 or 311V (airfoil blade) or OFSD-311.
 - b. 3-Hr Rated Walls: Greenheck FSD-231.
 - c. Stainless Steel: Greenheck SSFSD-211 or SSFSDR-511 (round).
5. Actuators: Electric 2-position, 115/1/60 (provide factory wired transformer if required), normally closed, spring return, NEMA-1 except as noted. Actuator shall fully re-open damper when power is restored after any power interruption.
6. Accessories
 - a. Transitions: Provide round-to-rectangular, oval-to-rectangular, or rectangular-to-rectangular transitions as appropriate for the application.
 - b. Thermal Link: Provide re-settable bi-metallic thermal link to initiate closure when the air temperature within the duct rises to 165o F. Where indicated provide thermal links for operation at 212o F, 250o F, or 350o F. Thermal link shall be easily resettable from outside the duct.
 - c. Position Switches: Provide dry contacts for remote monitoring of damper open and closed positions.
 - d. Retaining plates and angles: Provide as required. Galvanized steel specifically designed for the particular FSD and included as part of the UL Listed assembly.
 - e. Installation decals: Provide installation decals on the sleeve which give the installer clear installation instructions.
 - f. Temperature Override Control: Provide controls so that the thermal link can be over-ridden and the FSD opened for smoke control, even if the air temperature exceeds the setting of the thermal link, provided the temperature does not exceed 350o F.

C. Smoke dampers: Similar to fire/smoke dampers noted above, except as follows:

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1. Smoke dampers shall comply with UL 555S, but need not comply with UL 555.
 2. Smoke dampers need not have a fire rating.
 3. The thermal link and temperature override are not applicable.
 4. Suitable for installation within a wall, floor or ceiling assemblies as indicated.
 - a. Ratings, except as noted: Leakage Class 1, 350o F, 4-inch Static Pressure, Dynamic.
 - 1) Up to 1600 FPM: Greenheck SMD-201 (3-V blade type) or SMDR-501 (round).
 - 2) Up to 3000 FPM: Greenheck SMD-301, 301V (airfoil blade) or SMDR-401.
 - b. 6-inch pressure rated: Similar to Greenheck SMD-401
 - c. Stainless Steel: SSSMD-201 & SSSMDR-501 (round).
- D. Fire Dampers: Dynamic rated, suitable for closing against 8-inch differential pressure. Curtain type with sleeve and 165oF replaceable fusible link, resettable. Provide round-to-rectangular, oval-to-rectangular, or rectangular-to-rectangular transitions as appropriate.
1. 1.5-hr rated: Greenheck DFD-155
 2. 3-hr Rated: Greenheck DFD-355.
 3. Provide 212o F fusible links for high temperature applications.
- E. Ceiling Radiation Dampers: UL Classified for use with fire rated floor/ceiling assemblies, with 165oF fusible link replaceable through the damper assembly, 1.5-hr rated except as noted. Greenheck CRD-1, CRD-2 (round), CRD-60, or CRD-60X. Provide 212o F fusible link and 3-hr rated dampers where indicated.

2.4 FILTERS AND FILTER GAUGES

- A. Rated per ASHRAE Std. 52.1; Class 1 or 2 per UL Std. 900; glass fiber media; suitable for operation from -20o F to +170o F; corrosion resistant; suitable for installation with pleats either horizontal or vertical, and for air flow horizontal, vertical upflow, or vertical downflow; suitable for face velocity up to 625 FPM. Unless specified elsewhere, filters shall be MERV-13 or MERV-14. AAF, Camfil Farr, or approved equal.

2.5 TERMINAL UNITS

- A. General: Factory packaged unit with casing, air valve, air flow sensor. If the following sections are specified or required, provide them as part of the factory package: heating section, fan, and sound attenuator. Terminal units (TUs) shall be suitable for variable volume operation over the scheduled air flow ranges. Air flow and sound performance shall be rated per ARI 880. All materials in the air stream shall comply with the requirements of UL-181 and NFPA-90A.
1. Unit Construction:
 - a. Casing: Minimum 22-gauge galvanized steel with round inlet collar, rectangular outlet collar, 3/4-inch acoustic lining with cut edges coated with sealant.
 - 1) **UL 723 – 25/50 flame & smoke**
 - 2) **ASTM E84 – 25/50 flame & smoke**
 - 3) **ASTM C665 – Fungi Resistance**
 - b. Air Valve: Heavy gauge metal damper, shaft to extend through casing, self-lubricating bearing, with leakage not to exceed 2% of rated air flow when closed with 3-inch inlet pressure.
 - c. Air Flow Sensor: Cross configuration located at inlet of assembly, accurate to within 5% with 90o elbow directly at inlet connection. Provide

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- d. Sound Attenuator: Galvanized steel with acoustic lining. Provide aluminum liner if specified for casing.
 - 1) Electric Heaters: Factory installed and wired with all necessary safety controls, UL listed as an assembly, with galvanized steel enclosure, 80/20 nickel chrome heater elements, electronic modulating control with 4-20 mA input signal from DDC system, air flow switch, access door with door interlock disconnect switch, automatic reset primary thermal cutout switch, manual reset secondary thermal cutout, 24-V control transformer, NEMA-1 enclosure for all electrical components with hinged access door with wiring diagram. Controller shall be solid state type to minimize electrical interference and for silent operation.
 2. Sound Data: The equipment schedules show maximum allowable NC levels based on unit sound power measured per ARI-885, and sound attenuation per ARI-885 Appendix E with a Type 2 ceiling. Do not exceed the scheduled sound levels.
 3. Controls: Controls will be supplied by the controls contractor for installation by terminal unit (TU) supplier. Coordinate with controls contractor who will ship controls to TU manufacturer. TU manufacturer shall install controls onto terminal units.
 4. Approved Manufacturers: Trane, Price, Anemostat, Titus, Krueger, or approved equal.
- B. VAV Reheat: Single duct type with reheat as indicated.

2.6 GRILLES, REGISTERS AND DIFFUSERS

- A. General: Performance rated per ASHRAE Std 70, *Method of Testing for Rating the Performance of Air Outlets and Inlets*, steel with baked white enamel finish except as noted, for installation on a fixed surface or a lay-in T-bar ceiling as indicated on architectural drawings, rigidly constructed, vibration free, with inlet collar of sufficient length to connect inlet ductwork, sized as shown on drawings. Where frames are provided for installation in fixed surfaces, frames shall be approximately 1-1/8" wide. Sound performance rated per ADC and based on room absorption of 10dBre10-12 Watts and one diffuser.
 1. Approved Manufacturers: Price, Krueger, Titus, Anemostat, OAE
- B. Types as follows. See also the Grille and Diffuser Schedule on drawings.
 1. Square Ceiling Diffusers: Louvered type, 4-way pattern, 1-piece smooth aerodynamic surfaces with no corner joints, three louvers for 12-inch sizes, four louvers for 24-inch sizes, removable louver assembly, round neck, to provide stable, horizontal air flow without dumping down to 75 FPM inlet velocity for ceiling applications, and down to 20% of maximum air flow for non-ceiling applications. Price SCD.
 2. Round Ceiling Diffusers: Louvered type, 360-degree distribution, four separate 1-piece smooth aerodynamic louvers, adjustable air flow pattern (horizontal vs. vertical), round neck. Price RCD.
 3. Ceiling Return, Exhaust and Transfer Grilles: 1/2" x 1/2" x 1/2" egg crate type, steel frame for surface mounting or T-bar ceiling per application, aluminum grid. Price Series 80.
 4. Ceiling Rectangular Directional Diffusers: Louvered type, directional pattern as indicated on drawings, with removable louver assembly. Price SMD.
 5. Sidewall Supply Registers: Double deflection with ganged horizontal front bars, individually adjustable vertical rear bars, 3/4" bar spacing and surface mounting frame. Price 520.
 6. Sidewall Return, Exhaust and Transfer Grilles: Fixed horizontal bars on 3/4" centers set at 30-45 degrees, surface mounting frame. Price 530.

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7. Ceiling or Sidewall Linear Supply Diffusers: Extruded aluminum with baked white enamel finish, frame suitable for lay-in or surface mounting as per the architectural drawings, all aluminum construction, flat black interior surfaces, air flow deflection vanes to provide each slot with individually and fully adjustable 180o air pattern from horizontal to vertical or in between, self-aligning devices to ensure proper alignment where multiple sections are required, and corner pieces as necessary for a continuous appearance. Provide galvanized steel side inlet plenum matched to diffuser, with plenum extension if necessary to match adjacent construction. Performance data is based on 3/4-inch slots unless otherwise indicated. See plans for required air flow, diffuser length, and number of slots. Price SDS with SDA or SDB plenum, Krueger 1910, or equivalent.
8. Ceiling or Sidewall Linear Return Registers: As specified for sidewall linear supply diffuser except without air flow deflection vanes. Price SDS.
9. Stainless Steel Sidewall Return/Exhaust Registers: Fixed horizontal blades at 1/2" spacing and 45o deflection, flange for surface mounting, and SS 90o quick-release fasteners to mount grille to frame. Provide mill finish for blades and No. 4 finish for flanges. Price Model 735H.
10. Stainless Steel Slot Diffuser: Consist of a 0.037", 304 stainless steel plenum with continuous welded joints and chamfered corners to facilitate cleaning. The diffuser face shall be stainless steel construction with slots and fixed pattern deflectors. Plenums shall have stainless steel inlet collars complete with removable dampers from plenum face. The removable dampers shall be opposed blade type, constructed of stainless steel. Damper shall be adjusted without removing face of diffuser. The diffuser face shall be attached by stainless steel 90o quick-release fasteners and safety cable to open easily. The diffuser face, mounting frame, face and interior surface of plenum shall have a #4 finish. Krueger Model HORDSS or equivalent.
11. Laminar Flow Diffuser: Extruded aluminum construction and plated steel to inhibit corrosion. The perforated face plate, damper deflector, interior baffles and diffuser back pan plenum assembly shall be of 0.040 aluminum. The perforated face plate shall open easily with 90o quick-release fasteners and safety cable for easy cleaning and damper adjustment. B11 Sterile White-Thermal Setting finish. Krueger Model LFD or equivalent.

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2.7 FANS

A. General

1. Construction
 - a. Factory fabricated fan, motor, drive and accessories, listed per **UL-705**, with air flow rated per AMCA 211 and sound rated per AMCA 300 & 311.
 - b. Fan wheel: Statically & dynamically balanced, with shaft sized so first critical speed is minimum 25% above maximum operating speed.
 - c. Motor and Drive: Premium efficiency ODP motor per Spec Section 23 0500, direct drive or belt driven as indicated in schedule on drawings, bearings with 100,000 hr L-10 life.
 - 1) Variable Speed Applications: Provide Class F insulation.
 - d. Belt Drives: Adjustable pitch sheave up to 5 Hp, fixed pitch above this Hp, cast and machined pulleys with all components sized for 150% of motor Hp.
 - e. Dampers:
 - f. Accessories:
 - 1) Roof Curb: Minimum height per drawings, galvanized steel, fiberglass insulated, with wood nailer, damper tray and flange. Provide cant and step if needed for proper seal with roof.
2. See Section 23 0548 for Vibration Isolation requirements.

B. Centrifugal Roof Exhaust Fans

1. Leakproof construction.
2. Housing: Spun aluminum construction, reinforced wind band welded to one-piece curb cap with mounting holes on the side and integral spun venturi, spun aluminum motor compartment with readily removable cover and breather tube. All other structural components shall be galvanized steel.
3. Fan wheel: Backward inclined, centrifugal, non-overloading.
4. Motor and Drive: Motor out of the air stream, cooled with ambient air. Motor, drive and fan wheel resiliently mounted on neoprene isolators.
5. Electrical: Disconnect NEMA-1 if protected from the weather, or NEMA-3R if exposed to the weather, wired to motor, with all wiring and components per NEC and either UL Listed or UL recognized.
6. Accessories: Stamped aluminum nameplate, hinge kit to allow tilting fan up to inspect wheel, retaining chains, conduit chase and roof curb.
7. Approved Manufacturers: Greenheck Type, G, GB, CUE or CUBE as indicated. Cook, ACME, OAE.

C. Utility Set Exhaust Fans.

1. xx
2. Approved Manufacturers: Greenheck, OAE.

2.8 AIR HANDLING AND AIR CONDITIONING UNITS

- A. See Specification 23 7413

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PART 3 - EXECUTION

3.1 DUCTWORK AND PLENUMS

A. Ductwork

1. Construct ductwork with wall thicknesses and reinforcing per the SMACNA HVAC Duct Construction Standards, Second Edition, 1995, and UMC 2021 Chapter 6,
2. Pressure Classes: Construct ductwork to the following pressure classes:

<u>Duct Element Description</u>	<u>Relative Pressure</u>	<u>Pressure Class</u>
From Air Handling Unit to Terminal Unit	P	4"
From Single Zone AHU to Diffuser	P	2"
From Exhaust Register to Exhaust Fan	N	2

3. Minimum thickness for sheet metal ductwork: 26 gauge.
4. Sealing: Seal ductwork and plenums as follows:

Location	Seal Class			
	Supply Ducts			
	<2 in wg	>2 in wg	Exhaust	Return
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces including RA Plenums	C	B	B	A

Seal Class Description

- A. All transverse joint, longitudinal seams and duct wall penetrations.
- B. All transverse joints and longitudinal seams.
- C. Transverse joints.
 - a. Apply duct sealer to inside of seams and joints. Do not use pressure sensitive tape as the primary sealant.
5. Clearance to earth: Maintain minimum 4-inch separation between ductwork insulation and earth.
6. Openings in Ductwork: During in-stallation protect the open ends of ducts to prevent debris and dirt from entering.
7. Provide turning vanes in square elbows of low velocity supply and exhaust ductwork.
8. Collars: Where exposed ducts pass through walls, floors, or ceilings, provide a tight-fitting, flanged sheetmetal collar around duct and tight against finished surface to cover opening and present a neat appearance. Lock collar to duct.
9. Cross Breaking: Cross-break low velocity rectangular sheetmetal ducts on all four sides. Cross break sheet metal between standing seams or reinforcing angles. The center of cross break shall be of the required height to assure surfaces being rigid. Do not cross-break high velocity plenum panels.

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10. Grilles Registers and Diffusers: Install plumb, affix to general construction as appropriate, make air-tight connection to ductwork, and adjust air flow pattern to achieve appropriate velocities in the occupied zones. Request direction from Engineer if any question exists regarding proper air flow adjustment.
 11. Duct Thermometers: Provide thermometers to indicate mixed air, outside air, and supply air of indoor air handling units over 2,500 cfm and where shown on the Drawings.
 12. Test Holes: Provide test holes in ducts at locations where testing is required per Section 23 0593 and as requested by the T&B agent. Close test holes with rubber plugs. Reseal all insulated ductwork with the same insulation, jacket and vapor barrier material after T&B is complete.
 13. Closure Systems:
 - a. Rigid Air Ducts: Comply with UL 181A – Standard for Closure Systems for Use with Rigid Air Ducts and Air Connectors.
 - b. Flexible Air Ducts: Comply with UL 181B – Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors.
 14. Factory Made Air Ducts: Install in accordance with the terms of their listing and the manufacturer’s recommendations.
 15. Acoustic Insulation: See Section 23 0700, HVAC Insulation. Fabricate ductwork so the dimensions indicated on the drawings are the clear dimensions for air flow inside the acoustic insulation.
 16. Coordination with Building Construction
 - a. General: The drawings show the general intended configuration of the ductwork. Provide additional offsets where necessary to coordinate with the building construction or with the work of other disciplines. Transition ductwork as required at no change in contract price. Where this is necessary, submit for review and maintain the indicated flow areas.
 - b. Ductwork is frequently routed through bar joists and between bar joists. Coordinate duct locations with joist submittals prior to fabrication.
- B. Special Applications
1. Fume Hood Ductwork: Stainless steel with seams and joints continuously welded on the exterior. Spiral lock seam is not acceptable.
- C. Fiberglass Ductwork (Ductboard)
1. Provide fiberglass ductboard only where specifically indicated on the drawings and in this specification.
 2. Install per UMC-06 Standard 6-05 – Standard for Installation of Factory-Made Air Ducts and SMACNA Standard 1884-2003 – Fibrous Glass Duct Construction Standard.
 3. The drawings indicate required clear inside dimensions for air flow.
 4. Where a duct constructed of ductboard penetrates a wall or floor which requires a fire damper, smoke damper, or fire/smoke damper, install the FD, SMD or FSD in the wall per its listing, make sheet metal connections to the damper if required, and then transition back to ductboard.
 5. Exterior Ductwork: Install ductwork as specified herein and insulate per Section 23 0700. Then enclose the exposed top and sides of ductwork with 28 gauge galvanized steel or 26-gauge aluminum to protect the insulation. Repair any damage to the insulation jacket. Slope sheet metal enclosure to shed water.

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D. Hangers and Supports

1. Securely support ducts per SMACNA and UMC Table 6-7. Provide support at each concentrated load and at each change in direction. Provide supports on each side of rectangular ducts and equipment. Where vertical ducts pass through floors or roofs, support with angles or other steel members attached to minimum two opposite sides of duct. Size supports to rigidly support the ductwork. Provide lateral support.
2. Hangers for terminal units: Minimum four 1" x 1/8" galvanized steel straps or two angle trapeze supports.
3. Horizontal Round Ducts: 30 inches and larger in diameter: Provide 2" x 2" x 1/8" black steel rolled angle ring on 6-ft centers, and support from angle.

E. Plenums

1. Single Wall Plenums: Shop fabricated minimum 16 gauge galvanized sheet steel. Horizontal and vertical panels are to be fabricated of 2' x 10' sheets. Unless otherwise dimensioned on the Drawings, access door frames are not to exceed 16-3/4 inch width. Where door width exceeds 16-3/4 inches, vertical panels shall be fabricated around 2" x 2" x 1/4" angle. If the plenum height or width exceeds 9 feet, provide a 2-1/2" x 1/8" continuous galvanized steel strip between each horizontal and vertical seam. Provide high velocity cement at each joint during panel assembly. Panels are to be bolted as shown on the details or tack welded at the Contractor's option; however, enough panels must be bolted to allow removal of equipment from the plenums. Cover interior surfaces with 2-inch thick, acoustical lining.
 - a. Plenum Access Doors: Minimum two fastening devices that can be operated on either side of the door; these devices to be readily operated and moving parts to have bronze pins. All parts of the door shall be constructed of galvanized iron and shall be airtight. Latches: "Ventlock" No. 310 OAE.
2. Double Wall Plenums: Factory fabricated, Semco or equivalent. Submit shop drawings for review including overall configuration, construction details, access doors, erection drawings and structural calculations stamped by a registered structural engineer,.
 - a. Factory fabricated, minimum 18 gauge galvanized steel outside, perforated galvanized steel inside, with [4-inch] [2-inch] sound insulation between. Plenums downstream of final filters shall have solid inner panel.
 - b. Heat transfer coefficient shall not exceed 0.0575 BTUH/SF-F at 75 deg F mean temperature. Pressure Ratings: 12 in. wg positive and 10 in. wg negative.
 - c. Noise attenuation shall be as follows in decibels, re 10-12 watts.

	<u>OCTAVE BAND</u>							
	1	2	3	4	5	5	7	8
Attenuation, db	26	30	36	41	34	36	44	37
Noise Absorption Coeff	0.22	0.39	1.20	1.36	1.3	0.84	0.74	0.68

3.2 DUCTWORK ACCESSORIES

- A. Dampers: Install dampers with shafts horizontal. Locate dampers so that actuators are readily accessible. Verify that dampers operate smoothly.
 1. Manual Dampers (Balancing Dampers): Damper Types D1 through D23 are all suitable for use as manual balancing dampers. Provide locking quadrants.

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2. Automatic Applications: The following damper types may be used for automatic applications: D4, D5, D6, D7, D21, D22 and D23. Provide damper actuators per Section 23 0900.
- B. Flexible Connectors: Provide flexible connectors at locations indicated on the drawings and at the inlet and outlet of each fan directly connected to duct system. Select flexible connectors appropriate for the application. Provide steel spring vibration isolators spanning across flexible connections of isolated fan housings to prevent blow apart due to horizontal displacement of fan housings.
- C. Access Doors: Provide as required for access to all components located within ductwork. Locate to facilitate access to such components. Size as appropriate. In addition to locations specifically called out on the drawings or elsewhere in these specs, provide access doors at the following: FDs, SMDs, FSDs, instrumentation mounted within ductwork, fan bearings.
- D. Turning Vanes: Provide turning vanes in square elbows of all supply ducts. Single wall turning vanes may be used in ducts up to 1500 FPM and 24-inch vane length. Provide double wall turning vanes in ducts exceeding either of these criteria.
- E. Roof Curbs and Equipment Support Rails: Coordinate the location of roof curbs and rails with the roof structure, ductwork distribution, and other work. Install after roof deck is installed but before roof is insulated. Mount curbs and rails securely to deck per manufacturer's recommendations. Provide counterflashing as required.
- F. Louvers: Coordinate louver size and construction with structural and architectural openings to assure proper fit. Securely fasten louver to internal structural members to withstand a force of 25 lb/sf plus a safety factor of 3.0.
- G. Instrumentation: Install duct thermometers and filter gauges so they are easily readable from the operator level.

3.3 DAMPERS FOR FIRE AND SMOKE CONTROL

- A. Select FDs, SMDs and FSDs as appropriate to the application. Dampers may be rectangular or round, and single-section or multi-section as required, but shall not be less than the duct sizes indicated on the drawings nor larger than the maximum sizes per the UL listing for a given style of damper. Provide transitions and sleeves as required.
 1. FSDs may be used where SMDs are indicated provided they meet the required ratings of the indicated SMDs and provided the FSDs are installed in accordance with their listing.
- B. Install dampers in accordance with their listing. Terminate acoustic lining at dampers as necessary to ensure proper damper operation. Install actuators and access doors on the side of the duct unless space conditions preclude this. Provide adequate clearance for proper operation, and minimum 36-inch clearance for servicing actuator.
 1. When space conditions preclude installing actuators on the side, such components may be installed on the top or bottom of the duct provided good access to these components is maintained.
 2. When size requires the use of multiple dampers, provide framing to ensure the dampers remain in place.

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3. Provide a duct access door at each FD, SMD and FSD for inspection and maintenance. Provide minimum 1/2-inch high label, "SMOKE DAMPER," "FIRE DAMPER," or "FIRE/SMOKE DAMPER."
- C. Test all SMDs and FSDs after the system is installed to ensure proper operation based on both smoke and fire signals. Advise Owner minimum 2 weeks in advance and invite him to observe these tests. Submit a written report with a table which identifies each such damper (along with plans which indicate each such damper); gives its size, type and model number; the date on which it was tested; the test results; and places for the initials of the person performing test for the contractor and the person witnessing test for owner. Should any dampers fail to operate properly, service them and demonstrate proper operation. Reset all dampers when the testing is complete.

3.4 FILTERS AND FILTER GAUGES

- A. Provide one set of MERV-7 temporary filters until testing and balancing is complete. Then immediately before the system is turned over to the Owner at the completion of the project, remove these filters and provide the specified filters.

3.5 TERMINAL UNITS

- A. Install terminal units so that controls are readily accessible for normal service and maintenance. Provide minimum 3 ft clear in front of control panels.

3.6 GRILLES REGISTERS AND DIFFUSERS

- A. Install grilles, registers & diffusers (GRDs) square with building construction. Mount sidewall GRDs minimum, 3-inches above floor level. If GRDs have provisions to adjust the direction of air flow, submit a written recommendation regarding the best direction for air flows, obtain written approval from the Owner's Representative, and adjust GRDs accordingly.
- B. Verify frame types with architectural RCPs prior to ordering GRDs.

3.7 FANS

3.8 AIR HANDLING UNITS AND AIR CONDITIONING UNITS

3.9 CLOSEOUT ISSUES

- A. Leakage Testing
 1. Pressure test all of the installed ductwork of each system rated at 3 in wg or more, either positive or negative pressure. Advise Owner's Representative when systems will be ready for testing. For large systems separate tests may be made on different sections. The Owner's representative will designate the sections to be tested, but not more than 24 hours in advance of test. Cap ends of ducts as required and provide equipment as required for testing.

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2. Measure duct leakage per the SMACNA HVAC Duct Leakage Test manual. Leakage shall not exceed the following:
Lmax = CLP0.65, where
Lmax = maximum permitted leakage, cfm/100 sf of duct surface area
CL = Duct leakage class (cfm/100 sf at 1-inch wg)
 = 4 for rectangular sheet metal, rectangular fiberglass, and round flexible ducts
 = 3 for round and flat oval sheet metal or fiberglass ducts
P = Test pressure. Test pressure shall match system pressure class.
 3. If sample is defective, the contractor shall repair or modify the defective section and re-test it to demonstrate compliance. In addition, for each section which fails its original pressure test, the Owner's Representative will designate an additional ductwork section of similar size, for the Contractor to test.
 4. Complete all leakage testing and repairs prior to concealing ducts.
 5. Submit a test report that documents the test procedure and results. Include:
 - a. Test equipment – model numbers, technical data, calibration data, etc.
 - b. Drawings showing the extent of the systems tested.
 - c. Test results.
 - d. Dates, witnesses, and signatures of witnesses.
- B. Testing and Balancing: Test and balance the complete air tempering system as specified in Section 23 0593. It is anticipated that the TAB effort will identify some system deficiencies. Work in a cooperative manner to identify the cause of these deficiencies. Where deficiencies are due to defects in installation, or workmanship, repair as required and re-test to demonstrate proper performance.
- C. Cleaning
1. All ducts, coils, housing, registers, grilles, fans, etc., shall be clean when installed and shall be kept clean until the system is completed. As the various parts of the system are installed, they shall be wiped or blown clean and openings taped dust tight with heavy paper or cardboard until the system is completed and ready for testing. At that time all covers and protective wrappings shall be removed. Where one has been torn or previously removed, the duct, coil, register, etc., shall be carefully cleaned of any dirt or dust that has entered the opening.

END OF SECTION

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SECTION 23 7413- PACKAGED OUTDOOR CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged, outdoor, central-station air-handling units with the following components and accessories.
 - 1. Packaged Variable Air Volume Dx/Electric Heat
 - 2. Packaged Roof Top Unit Heat Pump- With Supplemental Electric Heat (Single Zone Constant Volume).

1.2 DEFINITIONS

- A. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- B. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- C. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
- D. Supply-Air Fan: The fan providing supply-air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.3 SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

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- E. Warranty.

1.4 QUALITY ASSURANCE

- A. ARI Compliance:
 - 1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
 - 2. Comply with ARI 270 for testing and rating sound performance for RTUs.
- B. ASHRAE Compliance:
 - 1. Comply with ASHRAE 15 for refrigerant system safety.
 - 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
 - 3. Comply with applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
- E. UL Compliance: Comply with UL 1995.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of air handlers that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 - 2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED VARIABLE AIR VOLUME DX/ELECTRIC HEAT

- A. BASIS-OF-DESIGN PRODUCT: Provide Trane or a comparable product by one of the following:
 - 1. Carrier
 - 2. York

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B. GENERAL

1. Unit furnished and installed shall be DX cooling, electric heat packaged rooftops as specified on the contract documents and within these specifications. Cooling capacity ratings shall be based upon AHRI Standard 340/360. Unit shall consist of insulated weathertight casing with compressors, air cooled condenser coil, condenser fans, evaporator coil, filters, supply and/or relief fan motors and drives, and microprocessor unit controls.
2. Unit shall be double wall, foam injected construction as manufactured at the factory. Package units shall be constructed for installation on a roof curb providing full perimeter support under air handler section and pedestal support under condenser section.
3. Unit shall be factory run tested to include the operation of all fans, compressors, heat exchangers, and control sequences.
4. Unit shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

C. CASING

1. Cabinet: Exterior panels shall be zinc coated galvanized steel painted with a baked enamel finish durable enough to withstand a minimum of 672 hours consecutive salt spray application in accordance with standard ASTM B117. Screws shall be coated.
2. Refrigeration components and compressor shall be accessible through removable louvered panels as standard.
3. Unit air handling section shall have a pitched roof and laminated double-wall construction with polyurethane foam core injected between sheet metal panels. Insulation value shall be R9. All interior surfaces shall be suitable for cleaning per ASHRAE 62. All access doors and panels shall have closed cell gaskets. All door, roof and base panels shall have a thermal break.
4. Unit base shall be watertight with heavy gauge formed load-bearing members and curb overhang. Unit lifting lugs shall accept chains or cables for rigging. Lifting lugs shall also serve as unit tie down points.
5. Access Doors: Access doors shall be hinged with a single, exterior mounted, height and tension adjustable handle to provide positive latching at three points. Access doors shall provide a door stop mechanism to latch the door in the open position to prevent unsafe door closure by wind. Serviceable compartments in the air handler such as filters, evaporator coil, supply fan and variable frequency drives shall have doors of laminated, double-wall construction. This construction shall use a polyurethane foam core between the exterior sheet metal pane and the interior line, with an insulating value of R9. Three single wall doors shall be provided for access to the control panel.

D. FANS- SUPPLY

1. Supply fan shall be two single width, single inlet 9-blade plenum fans. Fan blades shall be aluminum airfoil. Plenum fans shall be direct-driven. Entire assembly shall be completely isolated from unit and fan board by 2" deflection spring isolation.
2. Beltless fan shall not require routine maintenance such as fan bearing lubrication, belt tensioning and replacement, sheave alignment, and setscrew torque checks.
3. Supply fan motors shall be open drip-proof. All supply fans shall be dynamically balanced in factory. Each motor shall have its own Variable Frequency Drive.
4. Supply fan shall be test run in unit and shall reach rated rpm. All 60 Hz supply fan motors shall meet the Energy Independence Security Act of 2007 (EISA).
5. Provide a Supply Airflow Measurement (Piezometer). The Plenum supply fan shall have an airflow measurement device to measure differential pressure and to calculate fan airflow. The device shall be capable of measuring airflow within ± 5 percent total accuracy

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when operating within the stable operating region of the fan curve. Fan airflow performance and noise levels shall not be affected by the installation of the device. The fan inlet shall not be obstructed by the airflow measurement device.

6. Provide variable frequency drive (VFD) bypass. Supply fan bypass control shall provide airflow at 60 Hz in the event of drive failures.

E. RELIEF SECTION

1. Provide Relief Fan(s) - Direct Drive & Variable Speed with Statitrac Control. The eDrive™ relief fan shall be single-inlet, 5-blade direct-drive plenum fan(s) with backward inclined, high efficiency welded aluminum impeller that is dynamically balanced as an assembly. Fan shall be beltless and maintenance free throughout its operating life. Fan shall be balanced to G6.3 per AMCA 204. No external vibration isolation is necessary. Motor shall contain power electronics for speed control and be managed by the equipment controller. The modulating relief discharge dampers and ECM shall be modulated in response to building pressure. A differential pressure control system, (Statitrac™), shall use a differential pressure transducer to compare indoor building pressure to outdoor ambient atmospheric pressure. The relief fan shall be turned on when required to lower building static pressure setpoint. The (Statitrac™) control system shall then modulate the discharge dampers and ECM to control the building pressure to within the adjustable, specified dead band that shall be adjustable at the human interface panel.
2. Provide Ventilation Override Mode. With the ventilation override module installed, the unit shall be programmed to transition to up to 5 different programmed sequences for Smoke Purge, Evacuation, Pressurization, Purge, Purge with duct control sequence and Unit off. The transition shall occur when a binary input on the VOM is closed (shorted); this would typically be a hard wired relay output from a smoke detector or fire control panel.

F. OUTDOOR AIR SECTION

1. Provide 0-100 Percent Modulating Economizer. Shall be operated through the primary temperature controls to automatically utilize OA for "free" cooling. Automatically modulated return and outside air dampers shall maintain proper temperature in the space. Economizer shall be equipped with an automatic lock out when the outdoor high ambient temperature is too high for proper cooling. Minimum position control shall be standard and adjustable at the Human Interface Panel or with a remote potentiometer or through the building management system. A spring return motor shall ensure closure of OA dampers during unit shutdown or power interruption. Mechanical cooling shall be available to aid the economizer mode at any ambient.
2. Provide Economizer Control with Dry Bulb. Economizer control option shall include an outdoor temperature sensor for comparing the outdoor dry bulb temperature to a locally adjustable temperature setpoint. The setpoint shall be programmed at the user interface to determine if outdoor air temperature is suitable for economizer operation.

G. AIR FILTERS

1. Provide Air Filters. Filters shall mount integral within unit casing and be accessible via hinged access panels.
2. Provide filter monitoring. A factory-installed, differential pressure transducer shall be piped to both sides of the pre-evaporator filter to indicate status. Transducer shall maintain +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Transducer shall be mounted in a unit control box and report status through unit control display.

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3. Provide MERV 14 cartridge filters. Cartridge filters shall be 12-inch thick, MERV 14 microglass paper media attached to 24 ga galvanized steel frame, and shall slide into a galvanized steel rack. Option shall also include 2-inch thick, MERV 8 panel pre-filters of disposable synthetic media to provide extended cartridge life

H. DAMPERS

1. A. Provide Low Leak Economizer Dampers. Low leak dampers shall be provided with rolled stainless steel jamb seals to the sides of the damper assembly. Low leak economizer dampers shall have a leakage rate of 10 cfm/sq ft or less tested in accordance with AMCA Standard 500. Fault Detection and Diagnostic (FDD) control shall also be provided with Low Leak Economizers. FDD control shall monitor the commanded position of the economizer compared to the feedback position of the damper. If the damper position is outside +/- 10% of the commanded position, a diagnostic shall be generated

I. EVAPORATOR COIL SECTION

1. Provide heavy duty aluminum fins mechanically bonded to copper tubes. Evaporator coil shall be inter-circuited to maintain active coil face area at part load conditions. Coil shall also utilize internally enhanced tubing for maximum efficiency.
2. Provide electronic expansion valve. Shall be electronically controlled by the Symbio™ 800 unit controller. This fully integrates expansion valve control with unit operation to ensure optimal equipment reliability and efficiency. Expansion valves shall be 2500 step valves for precise refrigerant control and shall be driven closed during off cycles to minimize refrigerant migration and protect compressors. Valve position shall be displayed at the user interface to assist field diagnostics.
3. Provide stainless steel pressure transducer. Shall provide accurate measurement of high and low side refrigeration system pressure over the entire operating range. System pressures and saturation temperatures shall be displayed at the user interface to improve field diagnostics. The transducer is accessible as it shall be located close to the compressor manifold set. Durable weather proof automotive grade electrical connectors shall be used to ensure reliability.

J. AIR-COOLED CONDENSER SECTION

1. Condenser coils shall have all Aluminum Microchannel coils. All coils shall be leak tested at the factory to ensure pressure integrity. The condenser coil is pressure tested to 650 psig. Subcooling circuit(s) shall be provided as standard.
2. Provide subcooling circuit(s) integral with condenser coils to maximize efficiency and prevent premature flashing of liquid refrigerant, to a gaseous state, ahead of the expansion valve.
3. Provide vertical discharge, direct drive, condenser fans with aluminum blades and zinc plated steel hubs. Condenser fan motors shall be three-phase motors with permanently lubricated ball bearings, built-in current and thermal overload protection and weather-tight slingers over motor bearings.
4. Provide factory-installed louvered steel hail/vandal guards around perimeter of condensing section to protect the condenser coils, refrigerant piping and control components from damage resulting from hail, flying debris, and vandalism. Louvered panels shall be fabricated from heavy gauge, pre-painted galvanized steel with a baked, polyurethane enamel finish, and be rigid enough to provide permanent protection for shipping and pre-/post- installation.

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K. REFRIGERANT SYSTEM

1. Compressor shall be industrial grade, energy efficient direct drive 3600 RPM speed scroll type. The motor shall be of a suction gas cooled hermetic design. Compressor shall have a centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve. Crankcase heaters will be standard on each compressor to minimize amounts of liquid in the oil sump when unit is off.
2. Provide with thermostatic motor winding temperature control to protect against excessive motor temperatures resulting from over-/under-voltage or loss of charge. Provide high and low pressure cutouts, and reset relay.
3. Provide factory-installed compressor lockout thermostat to prevent compressor operation at low ambient conditions.
4. Provide coil frost protection compressor unloading based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage.
5. Trane® eFlex™ variable speed compressors shall be capable of speed modulation from 25 Hz to a maximum of 100 Hz. The minimum unit capacity shall be 15% of full load or less. The compressor motor shall be a permanent magnet type. Each compressor shall have a crankcase heater installed, properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles. Compressors shall be equipped with a bearing oil injection system that optimizes bearing and scroll set lubrication, sealing, and controls the oil circulation rate. Optimal bearing lubrication shall be provided by a gerotor oil pump. Each variable speed compressor shall be matched with a specially designed variable frequency drive which modulates the speed of the compressor motor and provides several compressor protection functions. Control of the variable speed compressor and inverter shall be integrated with the Symbio 800 unit controller to ensure optimal equipment reliability and efficiency.
6. Provide high efficiency units that shall meet ASHRAE 189.1-2011 and Consortium for Energy Efficiency (CEE) Advanced Tier Commercial Unitary AC and HP Specification for utility rebate requirements.

L. ELECTRIC HEATING SECTION

1. All electric heat models shall be completely assembled and wired. Electric heat control shall be fully integrated with the unit controls. Heavy duty nickel chromium elements internally wired with a maximum density of 35.5 watts per square inch shall be provided. Heater circuits shall be 45 amps or less, each individually fused. Automatic reset high limit control shall operate through heater.
2. Electric heat models shall include SCR control that modulates stage 1. Remaining stages are sequenced.

M. ELECTRICAL POWER CONNECTION

1. Provide Phase Voltage Monitor. Shall protect 3-phase equipment from phase loss, phase reversal and phase imbalance. Any fault condition shall produce a Failure Indicator LED and send the unit into an auto stop condition. cULus approved.
2. Provide Unit Interrupt Rating (Short Circuit Current Rating-SCCR). A 5,000 Amp rating Amp rating shall be applied to the unit enclosure using a non-fused circuit breaker for disconnect switch purposes. Fan motors, compressors, and electric heat circuits shall be provided with series rated circuit breakers that will provide the unit rated level of protection. The unit shall be marked with approved cULus markings and will adhere to cULus regulations.
3. Provide Non-Fused Disconnect. External handle mounted on the control box door shall be provided to disconnect unit power with the control box door closed for safety.

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N. CONTROLS -SYMBIO 800

1. Provide Symbio 800 Controls - The controller shall be an application-specific, programmable controller that is factory installed and designed to control packaged HVAC equipment. A 7" user interface features a touch-sensitive color screen that provides facility managers with at-a-glance operating status, performance monitoring, scheduling changes and operating adjustments. Other advanced features include automated controller backup on SD card and optional features such as secure remote connectivity, wireless building communications, mobile device connectivity and custom programming and expandable I/O
2. Provide Power Meter. Factory installed power meter shall measure unit energy usage to 0.2% accuracy (ANSI C12.20) and communicate through the Symbio 800 controller enabling viewing through user interface or building automation system.
3. Provide Controls Expansion Hardware. Symbio 800 shall have field applied controls capability. Factory installed expansion hardware (XM70) shall have 19 inputs/outputs.
4. Provide Multi Zone Variable Air Volume (Discharge Air Temperature). Option shall provide all necessary controls to operate a VAV rooftop from the discharge air temperature, including discharge air microprocessor controller and discharge air sensor. The controller shall coordinate the economizer control and the stages of cooling with discharge air temperature reset capabilities. Includes factory installed and tested VFDs to provide supply fan motor speed modulation.
5. Provide Trane BACnet Communication Protocol. The Symbio 800 controller shall support standard BACnet® communication protocol through a RS485, two-wire communication link or BACnet®/IP.

O. ACCESSORIES

1. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.
2. Coil guards of painted, galvanized-steel wire.
3. Hail guards of galvanized steel, painted to match casing.

P. CURBS

1. Roof curbs: Factory Fabricated Insulated Plenum Curb with Horizontal Duct Connections
2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C 1071, Type I or II.
 - 2) Thickness: 1.5" inch.
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C 916, Type I.
 - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - 3) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - 4) Liner Adhesive: Comply with ASTM C 916, Type I.
3. Curb Height: 46 inch tall plenum curb with horizontal supply and return duct connections.

Q. CAPACITIES AND CHARACTERISTICS

1. Supply and exhaust fans: See Equipment Schedule.

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2. Heating and cooling: See Equipment Schedule.
3. Sound Power: Radiated from condenser casing.

2.2 PACKAGED ROOF TOP UNIT HEAT PUMP- WITH SUPPLEMENTAL ELECTRIC HEAT (SINGLE ZONE CONSTANT VOLUME)

A. GENERAL

1. The units shall be convertible airflow. The operating range shall be between 115°F and 0°F in cooling as standard from the factory for units with microprocessor controls. Cooling performance shall be rated in accordance with ARI testing procedures. All units shall be factory assembled, internally wired, fully charged with R-410A, and 100 percent run tested to check cooling operation, fan and blower rotation, and control sequence before leaving the factory. Wiring internal to the unit shall be colored and numbered for simplified identification. Units shall be cULus listed and labeled, classified in accordance for Central Cooling Air Conditioners.

B. THROUGH THE BASE ELECTRICAL ACCESS

1. An electrical service entrance shall be provided allowing electrical access for both control and main power connections inside the curb and through the base of the unit.

C. THROUGH THE BASE ELECTRICAL WITH DISCONNECT SWITCH

1. This 3-pole, molded case, disconnect switch with provisions for through the base electrical connections. The disconnect switch will be installed in the unit in a water tight enclosure with access through a swinging door. Wiring will be provided from the switch to the unit high voltage terminal block. The switch will be UL/CSA agency recognized. The disconnect switch will be sized per NEC and UL guidelines but will not be used in place of unit overcurrent protection.

D. POWERED CONVENIENCE OUTLET

1. This is a GFCI, 120v/15amp, 2 plug, convenience outlet. A service receptacle disconnect shall be available. The convenience outlet is powered from the line side of the disconnect and therefore will not be affected by the position of the unit disconnect.

E. CASE

1. Unit casing shall be constructed of zinc coated, heavy gauge, and galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel finish. Unit's surface shall be tested 672 hours in a salt spray test in compliance with ASTM B117. Cabinet construction shall allow for all maintenance on one side of the unit. All exposed vertical panels and top covers in the indoor air section shall be insulated with a cleanable foil-faced, fire-retardant permanent, odorless glass fiber material. All insulation edges shall be either captured or sealed. The unit's base pan shall have no penetrations within the perimeter of the curb other than the raised 1 1/8" high downflow supply/return openings to provide an added water integrity precaution, if the condensate drain backs up. The base of the unit shall have provisions for forklift and crane lifting, with forklift capabilities on three sides of the unit.

F. UNIT TOP

1. The top cover shall be one piece construction or, where seams exist, it shall be double-hemmed and gasket-sealed. The ribbed top adds extra strength and enhances water removal from unit top.

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G. FILTERS

1. MERV 13 Throwaway filters shall be standard on all units.

H. COMPRESSORS

1. All units shall have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage. Internal overloads shall be provided with the scroll compressors.

I. REFRIGERANT CIRCUITS

1. Service pressure ports, and refrigerant line filter driers are factory-installed as standard. An area shall be provided for replacement suction line driers.

J. EVAPORATOR AND CONDENSER COILS

1. Internally finned, 5/16" copper tubes mechanically bonded to a configured aluminum plate fin shall be standard. Coils shall be leak tested at the factory to ensure the pressure integrity. The evaporator coil and condenser coil shall be leak tested to 650 psig and pressure tested to 450 psig. The condenser coil shall have a patent pending 1+1+1 hybrid coil designed with slight gaps for ease of cleaning. A removable, reversible, double-sloped condensate drain pan with through the base condensate drain is standard.

K. OUTDOOR FANS

1. The outdoor fan shall be direct-drive, statically and dynamically balanced, draw-through in the vertical discharge position. The fan motor shall be permanently lubricated and shall have built-in thermal overload protection.

L. INDOOR FAN

1. All high efficiency shall have variable speed direct drive motors. All motors shall be thermally protected. All indoor fan motors meet the U.S. Energy Policy Act of 1992 (EPACT).

M. CONTROLS

1. Unit shall be completely factory-wired with necessary controls and contactor pressure lugs or terminal block for power wiring. Unit shall provide an external location for mounting a fused disconnect device. A choice of microprocessor or electromechanical controls shall be available. Microprocessor controls provide for volt control functions. The resident control algorithms shall make all heating, cooling, and/or ventilating decisions in response to electronic signals from sensors measuring indoor and outdoor temperatures. The control algorithm maintains accurate temperature control, minimizes drift from set point, and provides better building comfort. A centralized Microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.
2. Control System shall include a System Controller, all controllers for HVAC equipment and ancillary devices (such as lights and exhaust fans), wireless communication between the System Controller, equipment controllers, and space sensors, and all wiring and end devices required. Control System to be fully programmed and commissioned by the installing contractor.
3. Control System shall include a 10" color Touch Screen Display for use by building occupants to adjust zone temperature setpoints, override lighting and HVAC equipment for after-hours use, modify schedules, and view service notifications. This display shall have PIN access for users and provide setpoint adjustment limits.

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4. System Controller shall have an embedded Web Browser Interface to allow the installer and service providers to make adjustments to system control parameters and view trend logs and other service information.
5. System Controller shall provide scheduling and coordination of all HVAC equipment. The System Controller shall provide Demand-Controlled Ventilation with wall mounted CO2 Sensors for classroom / lab spaces (densely occupied spaces).
6. Installer shall provide secure remote access to the Control System to enable the owner or service provider to access the system remotely using the Mobile App or Web Browser Interface. The Control System must be secured behind a firewall and not allow any inbound ports to be open or exposed to the internet. Control System manufacturer shall provide a remote access portal accessible by the owner and/or a service provider (as authorized by the owner).
7. System Operating Modes
 - a. The System Controller shall send the equipment controllers Occupied/Unoccupied, Morning Warm-up/Pre-cool, and Heat/Cool modes. If communication is lost, the equipment controllers shall operate using default modes and setpoints.
 - 1) MORNING WARM-UP/PRE-COOL:
 - a) The RTU shall operate the supply fan and modulate (or cycle) compressors or modulate (or stage) heat to raise/lower zone temperature to its occupied setpoint. The OA damper shall remain closed, unless economizing.
 - 2) OCCUPIED HEAT/COOL:
 - a) The RTU shall operate the supply fan continuously and modulate (or cycle) compressors, modulate (or stage) heat, and/or enable airside economizing to maintain zone temperature at setpoint. The OA damper shall open to bring in the required amount of ventilation.
 - 3) NIGHT SETBACK:
 - a) During unoccupied mode, the system shall shut off. If the zone temperature drifts to the unoccupied heating or cooling setpoint, the system shall start up to heat or cool the zone, while the OA damper remains closed (unless economizing).
 - 4) DEMAND-CONTROLLED VENTILATION:
 - a) For those zones equipped with an occupancy sensor or CO2 sensor, outdoor airflow shall be reset based on occupancy status and/or measured CO2 concentration.
 - 5)

N. BACNET COMMUNICATIONS

1. The BACnet communications interface allows the unit to communicate directly with a generic open protocol BACnet MS/TP Network Building Automation System Controls.
2. Coordinate exact communication interface requirements with controls contractor.

O. PHASE MONITOR

1. Phase monitor shall provide 100% protection for motors and compressors against problems caused by phase loss, phase imbalance, and phase reversal. Phase monitor is equipped with an LED that provides an ON or FAULT indicator. There are no field adjustments. The module will automatically reset from a fault condition.

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P. ELECTRIC HEATERS

1. Electric heat modules shall be available for installation within basic unit. Electric heater elements shall be constructed of heavy-duty nickel chromium elements internally delta connected for 240 volt, wye connected for 480 and 600 volt. Staging shall be achieved through ReliaTel. Each heater package shall have automatically reset high limit control operating through heating element contactors. All heaters shall be individually fused from the factory, where required, and shall meet all NEC and CEC requirements when properly installed. Power assemblies shall provide single point connection. Electric heat modules shall be UL listed or CSA certified.

Q. ECONOMIZER

1. This accessory shall be available with or without barometric relief. The assembly includes fully modulating 0-100 percent motor and dampers, minimum position setting, preset linkage, wiring harness with plug, spring return actuator and fixed dry bulb control. The barometric relief shall provide a pressure operated damper that shall be gravity closing and shall prohibit entrance of outside air during the equipment off cycle. Optional solid state or differential enthalpy control shall be available for either factory or field installation. The economizer arrives in the shipping position and shall be moved to the operating position by the installing contractor.

R. ACCESSORY - ROOF CURB

1. The roof curb shall be designed to mate with the unit's downflow supply and return and provide support and a water tight installation when installed properly. The roof curb design shall allow field fabricated rectangular supply/return ductwork to be connected directly to the curb. The curb height shall be 18" tall. Curb design shall comply with NRCA requirements. Curb shall be shipped knocked down for field assembly and shall include wood nailer strips.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to ARI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Install condensate drain, minimum connection size, with trap and indirect connection. See Plumbing drawings.
- D. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 1. Install ducts to termination at top of roof curb.
 2. Connect supply ducts to RTUs with flexible duct connectors specified in Division 23 Section.
 3. Install return-air duct continuously through roof structure.

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3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.
- C. Tests and Inspections:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.

3.3 CLEANING AND ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.
- B. After completing system installation and testing, adjusting, and balancing air handling equipment and air-distribution systems, clean filter housings and install new filters.

END OF SECTION

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SECTION 25 35 00- FIELD DEVICES

PART 1 - GENERAL

1.1 OVERVIEW

- A. The Scope of Work described in this Section and as shown on the Control Drawings shall be provided and installed under this Section of the Specification.

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 23 05 00, Common Work Requirements.
- B. Section 23 05 49, HVAC and Electrical Installation Coordination.
- C. Section 23 05 93, Testing, Adjusting and Balancing.
- D. Section 25 50 00, Controls - Environmental Management System.

1.3 SCOPE

- A. It is the intent of this Section to specify the field devices necessary to provide fully automatic control for all systems as shown in the Control Drawings, stated in the sequences of operation, indicated in the electrical ladder diagrams, or as otherwise required by the Contract Documents. Some equipment controls are specified to be provided in other portions of the Contract Documents, including Owner-furnished equipment. As work of this Section, coordinate with these other suppliers and trades to provide a completely and fully functional EMS.
- B. It is the responsibility of the bidder to read and conform to all Sections of the Specifications, review all Contract Drawings of all divisions, and coordinate with all equipment suppliers of material specified under other Sections of the Specifications

1.4 SUBMITTALS

- A. Refer to Section 25 5000 for submittal requirements.

1.5 RECORD DRAWINGS

- A. Refer to Section 25 5000 for record drawing requirements.

1.6 SYSTEM TESTING

- A. Refer to Section 25 5000 for system testing requirements.

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1.7 TRAINING

- A. Refer to Section 25 5000 for training requirements.

1.8 SERVICE AND WARRANTY

- A. Refer to Section 25 5000 for service and warranty requirements.

PART 2 - PRODUCTS

2.1 FIELD DEVICES

- A. All devices and equipment shall comply with all applicable local code requirements.
1. Temperature Sensors - with accuracy of + .5 deg F @ 77 deg F).
 2. Pressure Sensors – sized as needed for best accuracy.
 3. Dampers, sized for specific application.
 4. Damper Operators, sized for specific application.
 5. Low Temperature Detection Stat – Manual reset. Shall be hard-wired to motor control center with a second contact for DDC alarm generation.
 6. All field mounted damper actuators, and sensors shall have engraved type nameplates attached by stainless braid or other permanent type attachment. ID tag shall identify the device as shown on submittal drawings. Dymo type labels shall not be acceptable.
 7. Field devices such as relays shall be located in each equipment’s respective control panel. Wall mounted devices are not acceptable. All field control panels containing devices shall be equipped with a hinged, lockable door. Each panel, and all devices inside each panel, shall bear engraved identifications as shown on submittal drawings. Do not attach nameplates to devices, rather attach to mounting back plane. All devices shall be wired through a wiring terminal strip located within the panel. Each terminal shall be identified to match submittal drawings.
- B. Sensors
1. General: Provide temperature sensors for duct, immersion, remote probe, and outside air applications.
 - a. Sensor time constant response to temperature change time shall be less than 3 seconds per degree change. Sensors requiring field-calibration shall not be acceptable. All sensors shall be precise and accurate so that they do not require adjustments or calibrations. Linearizing, ranging and resistance change versus temperature curve interpretations, where required, shall be made by software programming.
 - b. Minimum sensor operating ranges shall be as follows:
 - 1) Air Systems 0°F to 150°F.
 - 2) Outside Air 0°F to 120°F.
 - c. Sensor accuracy shall be $\pm 0.1\%$ at 32°F for platinum and nickel sensors and $\pm 0.4\%$ for thermistor sensors. Sensor to controlling device end to overall system accuracy, including errors associated with the sensor, lead wire and analog to digital conversion shall be $\pm 0.5\%$ for platinum and nickel sensors and $\pm 1\%$ for thermistor sensors.

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2. Duct Sensors: Provide flanged or threaded probe type sensors designed for duct type mounting. Sensor shall be encapsulated in an aluminum probe 4" long except where averaging sensors are specified. Sensors shall include a suitable junction box for terminating sensor wiring and shall include a lagging protrusion where installed in externally insulated ducts. Adjacent to each sensor provide a test hole plugged with a removable cap or plug to be used for test and calibration purposes. All sensors shall be located in the most easily accessible location while providing accurate sampling.
 3. Remote Probe Sensors: Provide remote probe sensors with sensing elements encapsulated in a nominal 2" stainless steel sheath suitable for return air or strap-on mounting. Sensors shall include a nominal 3' lead section and a suitable junction box for terminating sensor wiring.
 4. Outside Air Sensors: Provide shielded, weatherproof outside air sensors with sensing elements encapsulated in a nominal 2" stainless steel sheath suitable for outdoor applications. Sensors shall include a waterproof junction box or conduit body for terminating sensor wiring and a removable sun shield. Location shall be on exterior North-facing sidewall at a level requiring a 6' stepladder for servicing. Do not install at ground accessible level.
 5. Space temperature sensors shall be electronic type with a range of 32 deg F to 104 deg F. These sensors shall require no field calibration, but will be provided with a zero and span adjustment. They will have an accuracy of ± 0.4 deg F. All sensors shall use shielded cable between the sensor and the controller. Space temperature sensors for use with ASC's shall be provided with set point adjustment, local occupancy indication, communication jack for LAN connection, override switch.
- C. Pressure Sensors
1. Overpressure Protection: Provide pressure sensors impervious to instantaneous pressure changes of 150 percent of working pressure.
 2. Adjustment: Provide sensors with external adjustable span, adjustable zero and pulsation suppression (averaging type).
 3. Finished Spaces: Conceal pressure sensors in recessed stainless steel housing with removable perforated brushed stainless steel cover.
 4. Sensor Characteristics: Provide pressure sensors with the following characteristics:
 - a. Ambient Temperature: 40 to 140 degrees F.
 - b. Provide switching type sensors with platinum alloy, silver alloy or gold plated wiping contacts rated for the application, voltage and power levels.
 - c. Provide valved calibration taps adjacent to each pressure sensor for calibration.
- D. Differential Pressure Analog Sensors
1. Types: Provide differential pressure analog sensors of the solid state preamplifier types for electronic systems.
- E. Flow Sensors
1. General: Provide sensors for measuring flow in ductwork that are compatible with static pressure and differential pressure analog inputs of the electronic controllers served.
 2. Turndown: Provide sensors with an output which gives a continuous mathematical function over the full range of flow from maximum to minimum required.
 3. Location: Mount flow sensor concealed in public spaces or exposed in mechanical equipment room.

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F. CO2 Sensors

1. The CO2 sensor for demand control ventilation shall be a non-dispersive infrared sensor. The diffusion gas chamber in the sensor should incorporate a reflective light pipe or waveguide surrounded by a gas permeable 100 angstrom molecular sieve filter that prevents particulate contamination of the sensor. The infrared detector in the sensor should be internally heat stabilized at 50 deg C to eliminate external temperature interference. All adjustments to the sensor including output signal, output scaling, relay set point, relay dead-band, resetting CO2 calibration, and full two point calibration capabilities should be made via a user friendly PC based program that can communicate with the sensor.
2. Sensor shall have 20-30 VAC power input, 0-10V or 4-20mA analog output max. range, 0-10,000 ppm max. or factory set 0-5000 ppm measuring range.
3. Sensor shall be manufactured and warranted for 1 year by the controls vendor. During the initial 1 year period, recalibration required to keep instruments within original specifications shall be performed by the controls vendor at no cost to NMSU.
4. Provide at least one spare sensor to NMSU for future service needs. If the total count of sensors exceeds 10 provide at least two spare sensors.

G. Actuators

1. General: Provide electric motor driven actuators (operators) arranged "Fail Safe" in the event of power failure. Design operators to be quiet in operation and function within a range 85 to 100 percent input power potential.
2. Electric Actuators: Provide hydraulic or gear type electric actuators.
 - a. When operated at rated voltage each actuator shall deliver the torque required for continuous uniform movement of the control device from limit to limit.
 - b. Provide an integral end switch to limit travel and design the actuator to continuously stroke without damage.
 - c. Operators shall function properly within a range of 85 to 120 percent of line voltage. For actuators with input power greater than 100 watts, gears shall be ground steel, oil immersed, shaft shall be hardened steel running in bronze, copper alloy or ball bearing and operator and gear trains shall be totally enclosed in dustproof cast iron, cast steel or cast aluminum housing.
 - d. Actuators with input power less than 100 watts may use fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings and pressed steel enclosures.
 - e. Two position actuators shall be of the single direction, spring return or reversing type.
 - f. Proportioning operators shall be capable of stopping at all points in the cycle and starting in either direction from any point.
 - g. Reversing and proportioning operators shall have limit switches to limit travel in either direction.
 - h. For actuators with greater than 400 watts input, provide totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
3. Damper Operator Mounting: Mount damper operators where accessible for maintenance.
 - a. If located outside the duct or casing, mount operators on a 14 gauge reinforced support plate arranged to allow insulation between the support plate and the face of the duct or casing.
 - b. Brace damper operators rigid to show no deflection or movement over the full range of the damper stroke.

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- H. Current Sensing Relays
 - 1. Relays shall monitor AC current of motor loads. Switch shall have self wiping, snap acting Form C contacts rated for switching controller DC current as required. The set point of the contact operation shall be field adjustable.
- I. Static Pressure Safety Switch
 - 1. Air pressure switch shall be manually reset type, designed to sense static pressure and break an electrical circuit when the setpoint is exceeded. The setpoint shall be adjustable form 0.4" to 12" W.C. Unit shall be furnished and installed with a static pressure tip.
- J. Duct Static Pressure Probes
 - 1. Provide at each location indicated a duct static pressure probe capable of continuous monitoring of air static pressure. Each probe shall contain multiple static pressure pick-up points along the exterior surface of the cylindrical probe, internally connected to the averaging manifold. The station shall produce no measurable system pressure drop.
 - 2. Each probe shall be constructed of extruded aluminum with threaded end support rod and nut and mounting plate gasket.
 - 3. The probe shall produce a non-pulsating signal with a total accuracy of 0.5 percent of the total span.
- K. Building Static Pressure Probes
 - 1. Outside air static pressure probe shall be constructed of 10 gauge, anodized aluminum with a 2" diameter FPT connection. The probe shall be capable of sensing the outside atmospheric air pressure to within 2 percent of the actual value when subject to radial wind velocities up to 80 miles per hour with approach angles up to 30 degrees to the horizontal.
 - 2. Indoor static air probes shall be provided for each indoor air pressure measurement location. They shall be flush mounted with a concealed connection. They shall be constructed of 10 gage aluminum with a 1/8" coupling for output signal connection.

2.2 WIRING

- A. All wiring shall conform to the requirements of the NFPA 70 and Div 26 specifications. All control, power, and communication wiring of all voltages, including wiring in mechanical rooms or when exposed, shall be run in minimum 1/2-inch EMT. Control and power cables are NOT to be placed in the same conduit with communication cables.
- B. Wiring:
 - 1. All wiring used must comply in every detail to wiring standards as set forth by the system and/or device manufacturer.
 - 2. Wire for low voltage AC shall be minimum 300 volt insulated copper No. 18 AWG or larger conforming to NFPA 70, Type MTW, THHN, or TFFN.
 - 3. Cables carrying analog signals shall be shielded.
 - 4. Cables shall be terminated in solder or screw type terminal strips.
 - 5. Cables shall not be tapped at any intermediate points.
 - 6. All wire shall be color coded or numbered for identification. Identify as indicated on shop drawings and "As-Built" drawings. Cables and conductors shall be tagged at both ends with the identifier shown on the shop drawings.
 - 7. Wire terminating in screw type terminal strips shall have pressure connectors conforming to UL 486A, "Wire Connectors and Soldering Lugs for Use With Copper Conductors, or UL 486B, "Wire Connectors for Use with Aluminum Conductors."

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8. Wire terminations without connectors or traveling pressure pads will not be accepted.

PART 3 - EXECUTION

3.1 FIELD DEVICE INSTALLATION

- A. Space temperature transmitters shall be installed 60" A.F.F. If a setpoint adjustment is provided on the sensor then the unit shall be installed 48" A.F.F. unless otherwise specified on the plans.
- B. Outdoor air temperature elements shall be installed in a location that is continuously shaded and not effected by heat generating equipment or equipment intakes or discharges. The element shall be installed under a sun shield and high enough to avoid damage from vandalism.
- C. Duct point temperature elements shall be installed directly on ductwork and the connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Care must be taken to avoid direct contact between the temperature element and any heat transfer surface such as a coil.
- D. Duct averaging elements shall be installed with the same requirements as for the temperature point elements; however; the averaging elements shall be extended across the entire duct area in a zigzag pattern covering the entire surface area. Special clips shall be used to secure the elements at turns to prevent chafing of the elements. Where elements pass through a duct plastic tubing or similar protection shall be installed on the elements to prevent damage to the elements from vibration.
- E. Duct static pressure stations so that the direction of flow is observed when installing the probe to prevent measurement of total pressure. The connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Connections from the "HI" pressure port to the differential pressure transducer shall be 1/4" plastic tubing which shall not extend for more than ten feet. Pressure stations shall be installed 2/3 the distance down the duct of all major branch ducts or as indicated on the Drawings.
- F. All air differential pressure transmitters shall be installed within ten feet of the pressure sensing point. The transmitters shall be installed in a NEMA 1 housing for interior conditioned spaces and in NEMA 3R housings for outside or unconditioned spaces. The transmitters and housings shall be rigidly supported to prevent vibration and shall never be mounted to ductwork or piping. Access to the transmitter shall be provided.
- G. Current switches shall be installed in one leg of three phase circuits and the hot leg of single phase circuits and in all cases, after the local disconnect. The switches shall be adjusted to close at approximately 10% of the attached loads full load amps.
- H. Low limit thermostats shall be installed with the averaging element extended across the entire duct area in a zigzag pattern. Special clips shall be used to secure the element at turns to prevent chafing of the element. If an element passes through a duct, plastic tubing or similar protection shall be installed on the element to prevent damage to the element from vibration. The thermostat setpoint shall be set as indicated and the circuit shall be tested to ensure actions as required.

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- I. Outside air static pressure probes must be installed and piped according to manufacturer's instructions to ensure accuracy of the static pressure reading and eliminate the effects of condensation in the sensing lines. Coordinate installation of probes with the necessary trades for proper sealing of all roof penetrations.
- J. Air differential pressure switches shall be connected to pitot tube pickup probes pointing into the air stream on both sides of the process variable. Connections between the switch and the pitot tubes shall be 1/4" hard copper.

3.2 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

- A. Comply with all Division 26 installation requirements. All control, power, and communications wiring shall be installed in conduit.
- B. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.
- C. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- D. All wire-to-device connections shall be made at terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- E. Plug or cap all unused conduit openings and stubups. Do not use caulking compound.
- F. Route all conduit to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.
- G. Set conduits as follows:
- H. Expanding silicone firestop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.
- I. Oakum and lead, sealed watertight penetration through outside foundation walls.
- J. Cap open ends of conduits until conductors are installed.
- K. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18" and maximum length of 36" shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.
- L. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.
- M. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

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END OF SECTION

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SECTION 25 5000- ENVIRONMENTAL MANAGEMENT SYSTEM (BACNET PROTOCOL)

PART 1 - GENERAL

1.1 OVERVIEW

- A. The Scope of Work described in this Section and as shown on the Control Drawings shall be provided and installed under this Section of the Specification.
- B. This document contains the specification for development of the Environmental Management System (EMS) at New Mexico State University. At the building level the EMS system architecture utilizes intelligent distributed control modules located in each building which communicate using BACnet/IP (preferred) over Ethernet or BACnet MS/TP over EIA-485 Local Building Automation Networks. A given building commonly contains several such Local Building Automation Networks. A typical single network might serve all the terminal units on a single floor of the building. Another typical network might serve the various pumps, valves, VFDs, etc., making up the central mechanical system of a building.
- C. The Local Building Automation Networks communicate with each other and the university central monitoring and control system primarily through owner-provided Tridium Niagara AX Network Area Controllers (NAC). These are BACnet Building Controller (B-BC) devices which provide standard BACnet router and BBMD functions as well as BACnet/IP and MS/TP (master) connectivity. They also provide connectivity to the Owner's central monitoring and control system. (The PICS information for these devices is available upon request to the Owner's Environmental Systems Department.) All Local Building Automation Networks must be designed, configured, and installed for successful operation in this environment. The Local Building Automation Networks are private networks internal to the university and are not accessible for remote connections. All activities which require network connections (including but not limited to commissioning or maintenance) must be accomplished by the use of direct on-site physical connections. Any contractor or vendor equipment to be used on these networks must be registered in advance with the Owner's Environmental Systems Department.
- D. All normal operational user interface and Operator Workstation capabilities are provided by the Owner as part of the Owner's central monitoring and control system. The use of web interfaces is encouraged for purposes such as device configuration and any supplementary vendor-supplied graphic displays.
- E. The equipment connected on each Local Building Automation Network shall be designed, configured, and installed so as to maintain stable and safe operation of the equipment in the event of any failure of network communication with any other Local Building Automation Network or the university central system. If it is necessary that data be exchanged between equipment on different Local Building Automation Networks even while normal network connections through a NAC are disrupted then such interconnections shall be accomplished using hard-wired I/O points.
- F. All installed equipment must be fully compliant with ANSI/ASHRAE Standard 135-2004 (BACnet) and all published addenda at the time of installation. No gateways, non-compliant, or

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proprietary equipment or communication techniques of any kind are to be used on the Local Building Automation Networks.

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 23 05 00, Common Work Requirements.
- B. Section 23 05 05, Piping Specialties.
- C. Section 23 05 49, HVAC and Electrical Installation Coordination.
- D. Section 23 05 50, Variable Frequency Drives.
- E. Section 23 05 93, Testing, Adjusting and Balancing.
- F. Section 25 35 00, Controls – Field Devices

1.3 SCOPE

- A. It is the intent of this Section to provide, install, connect, program, and calibrate the additions and/or modifications to the EMS as necessary to provide fully automatic control for all systems as shown in the Control Drawings, stated in the sequences of operation, indicated in the electrical ladder diagrams, or as otherwise required by the Contract Documents. Some equipment controls are specified to be provided in other portions of the Contract Documents, including Owner-furnished equipment. As work of this Section, coordinate with these other suppliers and trades to provide a complete and fully functional EMS.
- B. It is the responsibility of the bidder to read and conform to all Sections of the Specifications, review all Contract Drawings of all divisions, and coordinate with all equipment suppliers of material specified under other Sections of the Specifications.
- C. The engineering, installation supervision, programming, calibration, startup, and checkout necessary for a complete and fully operational EMS, as specified hereafter, shall be provided under this Section.
- D. Provide training and instruction of the installed EMS.
- E. Provide the necessary materials and manpower to participate in the testing, adjusting, and balance and the commissioning process as required by those Sections of the Specifications.

1.4 SUPPLIER AND EQUIPMENT REQUIREMENTS

- A. EMS Supplier will be the authorized factory representative or branch office of the product manufacturer proposed. All software and hardware products shall be BACnet compatible to the level specified. (See also the Interface Specification submittal requirements of Section 1.5 B. 4.) No deviation from these requirements will be permitted.

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- B. The EMS contractor must be listed under the Owner's BACnet Pre-Qualification program, which includes specification of acceptable building automation devices. The firms listed under the program are:
1. Automated Control Systems – Albuquerque, NM
 2. Control and Equipment Company – El Paso, TX
 3. PC Automated Controls – El Paso, TX
 4. Trane Controls-El Paso, TX

1.5 SUBMITTALS

- A. Within thirty (30) days of Contract award, submit six (6) sets of Shop Drawings and Submittal Data in accordance with the General Contract Requirements and Submittal Requirements of this Section.
- B. Submittals shall consist of Shop Drawings, Catalog Data Sheets, Graphic Displays, and Software Development parameters as defined in the following paragraphs. No materials shall be purchased and no work shall be conducted at the job site until submittals have been reviewed and approved by the Owner.
1. Shop Drawings shall be provided which show detailed communications architectures (including the existing communication network), control devices, electrical ladder diagrams, control system schematics, Protocol Implementation Conformance Statements (PICS), sequences of operation, point lists (see section 1.5. B. 4.), and a material list. All systems and the associated control components as well as all connections between components shall be clearly indicated. The submittal shall indicate the required coordination with equipment supplied by sources other than this Section. The intention is for the Shop Drawings to be comprehensive enough for the installation crew to complete all aspects of the installation without the need for supporting documentation, except third-party equipment installation manuals. All wiring shown on the Drawings shall be labeled on both ends and these labels shall be used in the installation process for ease of comparing the Shop Drawings to the actual field installation. Each control component shall be given a unique identifier. This identifier shall be used in creating equipment field device labels and in the Sequence of Operation so that reference to the Drawings can be easily referenced.
 - a. Electrical Ladder Diagrams shall be shown on the Shop Drawings. Electrical Ladder Diagrams shall show the specific details of all switches, relays, motor starters, etc. The Electrical Ladder Diagrams shall show the correct control wiring and interlock wiring of all equipment provided under the Contract. Each diagram shall reference the correct power source by breaker panel and circuit number.
 - b. The Sequence of Operation for each controlled system shall be provided with reference to the control device identifier. The Sequence of Operation shall break down the control operation by major function (e.g., mixed air control, occupied unoccupied, smoke purge, etc.) and describe in detail the correct operation and interaction with other system functions. Use of the Sequences of Operation stated on the Contract Control Drawings is acceptable; however, they shall be modified to reflect actual control device identifiers.
 - c. A complete Material List shall be included on the Shop Drawings which show the device model numbers, control device identifiers, quantities, manufacturers, etc., of all equipment provided under this Section. The Material List shall be organized in alphabetical order so that it can be easily compared to the associated Catalog Data Sheets.

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2. Catalog Data Sheets will be provided for each different piece of equipment provided under this Section. At a minimum the Data Sheet shall contain sufficient information so that compliance with the Specification can be verified. Where multiple models or options are indicated on the same Catalog Data Sheet, the equipment proposed shall be highlighted or otherwise indicated. The Catalog Data Sheets shall be organized in alphabetical order to match the Material List on the Shop Drawings.
3. Point Verification forms shall be submitted for all points that will be installed as part of the EMS. Once approved, the Contractor shall complete the forms during startup to document successful point functionality. The completed forms shall be included as part of the record documentation. The Owner reserves the right to designate a representative to monitor completion of the Point Verification.
4. An Interface Specification shall be submitted as a Microsoft Excel spreadsheet describing each Local Building Automation Network including its BACnet network number, the complete list of devices to be placed on each such network, the BACnet Device Object instance number for each device, the BACnet object names and identifiers to be used within each device including identification of those objects for which commissioning trend logs will be provided, the MAC addresses of MS/TP devices, and all BACnet object cross-references between the devices on the complete set of Local Building Automation Networks. (A sample spreadsheet in the required format will be provided upon request to the Owner's Environmental System Department.) The BACnet network numbers and Device Object instance numbers must be selected from ranges requested by the Contractor from the Owner's Environmental Systems Department. The object names must have a <facility>.<system>.<point> structure such as "ALLIED.AHU_1.MA_TEMP", or "ALLIED.AHU_1.SA_TEMP" where the <facility> term must always be "ALLIED". The Interface Specification must be accompanied by a Microsoft Word or Adobe PDF document presenting the Protocol Implementation Conformance Statements (PICS) for all devices to be provided. No automation devices are to be installed prior to approval of the Interface Specification's complete contents by the Owner's Environmental Systems Department. The Interface Specification must include the MAC address for each Ethernet device. The Owner's Environmental Systems Department will then provide the IP address to be used for each of the devices.
5. If any graphics software is necessary (to provide capabilities beyond those which are provided by the Owner's central system) then all Graphic Slides (or typical graphics for identical equipment) proposed for use on this Project shall be submitted for review and approval. The submitted slides shall be printed in color. All realtime display fields, user input fields, etc., shall be clearly indicated. No graphic software shall be installed on the job site until the Graphic Slides have been approved.
6. Software Development parameters including all trend logs, reports, point alarm parameters, passwords, and scheduling shall be submitted based on the contents of this Specification Section. The information contained in this portion of the submittal will be followed during development of the programming code and shall be used for evaluation of the system's performance during the commissioning phase.
 - a. Report templates shall indicate what information will be presented on each report, how the information will be presented, report hard disk upload parameters, and report log file names.
 - b. If user authentication is required in any part of the installed system blank forms shall be submitted for completion of user information by the Owner. The forms shall allow the Owner to fill in the operator's name and approved password level. During Owner training, the EMS programmers shall coordinate with the approved operators to allow the operators to input their private passwords.

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- c. Blank schedule forms for each air handling unit shall be submitted for completion by the Owner. Additionally, a blank schedule group form template shall be submitted so the Owner can identify schedule groups of HVAC equipment.
7. The names, phone numbers, e-mail addresses, job descriptions, pager numbers, mobile phone numbers, etc., shall be provided for the project manager, project engineer, project programmer(s), installation foreman, and any other individuals key to the completion of this project. If at any time during the project the assignment of personnel changes, the Owner and the Engineer shall be notified and the previously listed information shall be furnished for the newly assigned individuals.

1.6 RECORD DRAWINGS

- A. Record Drawings shall be provided as required by the general Contract Requirements. Record Drawings shall not be completed until after installation is complete. Any changes made during installation shall be recorded on the Contractor's master record drawings as the changes are made so that a current Record Drawing is constantly being updated. These As-built Drawings shall be available at all times for inspection by the Owner, Engineer, or Owner's Representative. At completion of the Project, all hand-drawn field changes shall be incorporated into a clean reproducible set of As-built Drawings. These As-built Drawings shall be used during the training sessions.
- B. The Contractor shall furnish a complete spare parts lists, operating instructions, maintenance literature, and completed point verification forms.
- C. Record drawings shall be provided electronically and shall be directly editable using Autodesk AutoCAD 2008. Non-drawing project data shall be provided electronically as editable Microsoft Office 2003 documents.
- D. After final occupancy and all debugging have occurred, the Contractor shall deliver to the Owner all project-specific control software programs in an electronic format acceptable to the Owner; and all software used or needed to program, configure, install, commission, expand, or maintain any element or aspect of the installed system. All software packages must be permanently licensed in the name of the Owner and include full no-added-charge support by the manufacturer for the duration of the project warranty period.

1.7 SYSTEM TESTING

- A. At the termination of the point verification process, the Contractor shall submit completed and approved Point Verification forms for each point.
- B. Upon successful completion of all Point Verification testing, the Contractor shall submit hard copies of the Trend Logs called out in the approved Interface Specification (see section 1.5. B. 4.). The Trend Logs shall trend at least 48 hours of normal uninterrupted operation (non-weekend or holiday) for the purpose of documenting proper implementation of the control sequences of operation.
- C. The Owner reserves the right to participate in or assign a representative to participate in the startup, testing, programming, or any other aspect of the construction of this project at no additional cost to the Owner.

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1.8 TRAINING

- A. A total of eighty (80) hours of training time shall be provided by the Contractor.
- B. During the initial startup phase of the project, the EMS Supplier shall permit the Owner's operating personnel to be involved with the troubleshooting, initial startup, point verification testing, and performance trending.
- C. Prior to the final system trending, the Contractor shall provide three (3) days (20 hours) of training for up to six (6) Owner-designated operating personnel. The training shall cover all general aspects of the EMS system installation, wiring, calibration techniques, programming, troubleshooting, etc. The training shall not cover the details of this specific project. The training shall provide the same structure and depth as that provided to factory-authorized representative's installation and programming personnel.
- D. Upon completion and acceptance of the Work, provide three (3) days (20 hours) of training for up to six (6) Owner-designated operating personnel who have responsibility for the mechanical/control system. This training shall be conducted on site and shall focus on the specifics of this Project. A complete training booklet shall be provided and used during the training period. The booklet shall include the As-built Drawings.
- E. The EMS Supplier shall provide 40 additional hours of on-site training during the warranty period. The Contractor shall provide this training at the request of the Owner. The Owner will give at least one-week notice of the need for additional training. Warranty and service time shall not constitute training hours.

1.9 SERVICE AND WARRANTY

- A. The system supplier shall maintain a maintenance support facility complete with system technicians, diagnostic and test equipment, and new spare components. Emergency service shall be available in the local office on a 24 hour, 7 day a week basis. The service agent shall provide a continuously monitored local service telephone number for emergency service.
- B. Service and maintenance must be provided for one (1) year from time of Owner acceptance of the control system. If the manufacturer has a standard warranty that exceeds the specified requirement then the longer manufacturers warranty shall be provided to the Owner. Service during this period shall be available within 12 hours from the time the trouble call is placed. Warranty shall be for all materials and labor provided as the Scope of Work of this Section.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All products shall be selected in accordance with Part 2 of this Section. Installation of the components shall be in accordance with Part 3 of this Section.

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2.2 NETWORKING/COMMUNICATIONS

- A. Campus Local Area Network
 - 1. The Owner's Campus Local Area Network shall be used for interconnecting the Local Building Automation Networks and the Owner's central monitoring and control system.
 - 2. The Campus Local Area Network shall be extended as required by the Contract drawings and specifications.

- B. Local Building Automation Networks
 - 1. All BACnet controllers shall reside on a Local Building Automation Network. The Owner's Network Area Controllers are used for intercommunication between the Local Building Automation Networks, and between the Local Building Automation Networks and the Owner's central monitoring and control system.
 - 2. Development of the Local Building Automation Networks is work provided entirely under this Section of the Specification.
 - 3. All devices that reside on a Local Building Automation Network shall communicate in native BACnet. Proprietary protocols will not be permitted.
 - 4. The Owner's preference is that no more than 35 BACnet devices shall be placed on a single Local Building Automation Network. Approval will not be given for more than 60 BACnet devices on a single Local Building Automation Network network.

2.3 BACnet COMPATIBILITY

- A. All controller devices supplied to meet the functional and operational requirements of this specification shall conform, at a minimum, to one of the BACnet device profiles contained in BACnet, Annex L:
 - 1. BACnet Building Controller (B-BC), or
 - 2. BACnet Advanced Application Controller (B-AAC) or
 - 3. BACnet Application Specific Controller (B-ASC).

- B. The interoperability requirements of such devices are contained in Annex L of the BACnet standard. B-BC controller devices shall communicate using BACnet/IP. BACnet/IP is also preferred for other devices, but BACnet over MS/TP at 78.4 Kbps is acceptable. ARCNET at 156 Kbps is acceptable but only when accessed via a BACnet/IP router. No other protocols or techniques are acceptable.

2.4 INPUT/OUTPUT AND INTERLOCK WIRING

- A. Class I Circuits
 - 1. All materials required for installation of Class I circuits or circuits operating at greater than 48 VAC or VDC shall meet the requirements stated in Division 16, National Electric Code, and all applicable building codes as they apply to Class I circuits.

- B. Class II Circuits
 - 1. All materials required for installation of Class II circuits shall meet all requirements of the National Electric Code and all applicable building codes as they apply to Class II circuits.
 - 2. All cables shall be run in dedicated conduit no smaller than 3/4" or a metallic raceway and shall contain conductors per the manufacturer's recommendation for the application. The number of conductors shall be as required by the application and an overall foil shield with

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stranded drain wire shall be provided in all cases. The cable shall be factory stamped with a clear indication of the cable classification. The cable jacket shall be PVC. Metallic raceway and conduit shall be as specified in Division 16.

3. Local Building Automation Network cables shall be in dedicated conduit containing no other signal or power wiring.

PART 3 - EXECUTION

3.1 GENERAL

- A. All field hardware, control devices, conduit, wiring, etc., shall be provided as specified in Part 2 of this section and in Section 253500.
 1. The installation all aspects of the system shall comply with all applicable codes, regulations, and all related Contract Documents.
 2. The installation of all materials shall be in accordance with the published manufacturer recommendations without exception. If for some reason a particular component cannot be installed in compliance with these recommendations, the Contractor shall advise the Engineer of the situation.
 3. Where miscellaneous materials are required to complete an installation, i.e., isolation valves for pressure switches, wall switches for an exhaust fan control circuit, etc., the materials shall be supplied as defined in the relevant Section of these Specifications and installed under this Section of the Specification, unless otherwise noted.
 4. Coordinate with other trades where installation of a particular component requires other trades to be involved. Installation coordination includes location of the correct placement of thermowells, flow switches, dampers, control valves, control power circuits, etc. Care must be exercised to identify locations that meet the requirements of the manufacturer including upstream and downstream distances, pressures, temperatures, etc.
 5. All signal wiring requiring shielding shall have the shield terminated at the controller end only.
 6. Label all wiring with permanent labels indicating the point device identifier. Install a phenolic label mounted at the device indicating the device type and point identifier name.
 7. All field devices shall be labeled with 1" x 3" phenolic labels. Labels shall include the point name and device name. Labels for EMS controllers shall indicate the breaker and panel number of the power source. Labels shall be glued, attached with screws, or copper wire in the case of valves and actuators.
 8. On each terminal unit and fan control unit provide an adhesive film label showing the unit identification of the device as it appears on the construction drawings. The label shall be approximately three inches high by five inches wide, with the identification characters approximately one inch high. The characters shall be printed in black on an orange background. The label shall be placed on the unit at a location easily observable by maintenance personnel.
- B. All software development shall be completed by EMS programmers that have been factory trained in programming and graphic development techniques of the EMS.

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3.2 NETWORKING/COMMUNICATION

- A. General
 - 1. All LANs shall strictly be installed in a manner recommended by the manufacturer and Owner's communications personnel based on the environment, communications speed requirements, and distance. All LAN media shall be installed in a manner that provides protection from physical damage and interference from RF or other electrical sources.
- B. Campus Local Area Network
 - 1. All media required to connect Operator Workstations or Network Area Controllers to the Campus Local Area Network shall be installed with materials and procedures that comply with the requirements of the Owner's communications personnel and the EMS equipment manufacturer.
- C. Local Building Automation Networks
 - 1. The Local Building Automation Networks shall be installed with materials and procedures in strict compliance with the requirements of the EMS equipment manufacturer.

3.3 BACnet COMPATIBILITY AND OBJECT REQUIREMENTS

- A. All EMS software shall be developed in accordance with the approved PICS for the device. See Part 1 of this Section.
- B. The Out-Of-Service property shall be writable using BACnet services for all Analog, Binary, Multi-state, Loop, and Program objects.
- C. All Analog (Input, Output, and Value), Loop, and Multi-state (Input, Output, and Value) objects shall have the capability of using the Change of Value reporting mechanism and the COV-Increment shall be writable using BACnet services.
- D. PID loops shall be represented by Loop objects, with writable tuning constant properties.

3.4 NETWORK AREA CONTROLLERS (NAC)

- A. 120 VAC Power shall be provided to each NAC as the work of Division 16. If a NAC requires power at 48 VAC/VDC or lower or at a location other than as shown on the Drawings, it shall be the work of this Section to provide and install all necessary conduit, wiring, transformers, etc., and make the final connections. All power shall be verified as work of this Section prior to powering the controllers.
- B. It shall be work of this Section to provide connections of all NACs to the existing Campus Local Area Network and to the Local Building Automation Networks.

3.5 EMS CONTROLLERS

- A. General
 - 1. New controllers will be installed where required or indicated on the Drawings; however, in no case shall more than 90% of the maximum attached potential node limitations be

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designed nor shall more than 75% of the controller RAM be utilized by the programming code specified herein, including trendings and global programming. If these limits are met, additional controllers or RAM must be added.

2. All controllers shall be installed in accordance with manufacturer's instructions. Electrical power shall be provided to each device at the appropriate voltage and frequency. If a controller requires power at a different voltage or at a location other than as shown on the Drawings, it shall be the work of this Section to provide and install all necessary conduit, wiring, transformers, etc., and make the final connections. All power shall be verified as work of this Section prior to powering the controllers.
3. All EMS controllers shall be installed in a NEMA rated enclosure appropriate to the environment in which it will be installed that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure. If located outdoors or in mechanical rooms or similar harsh environments all penetrations of the enclosure shall be made through the bottom of the enclosure and not the top or sides.

B. Communications

1. It shall be work of this Section to develop the Local Building Automation Networks. This work includes installation and troubleshooting of new media. All devices shall be connected to Local Building Automation Network in a manner recommended by the manufacturer based on the environment, communications speed requirements, and distance.

C. Input/Output

1. The installation of all EMS field control components and the associated I/O wiring back to the respective controller will be installed under this Section of the Specification. Each point shall be checked by the Contractor for voltage, short circuit, etc., prior to termination to the controller to prevent any damage to the controller.

D. Software Requirements

1. All Sequences of Operation as stated in the Contract Documents are to be implemented.

E. Alarms

1. Alarms shall be provided as stated in the Contract Documents.
2. Alarms shall be suppressed when equipment has been intentionally forced to an inoperative status (e.g., night setbacks).

F. Minimum Runtimes

1. All digital output points shall have a minimum runtime as stated in the Contract Documents Sequence or Operations, otherwise as appropriate to the application, to prevent accidental short cycling.

G. Trend Analysis

1. The system shall be configured to trend those system points stated in the Contract Documents. Date and time stamps shall accompany all trend data. The initial interval for all trend logs shall be configured to be 15 minutes.

3.6 INPUT/OUTPUT AND INTERLOCK WIRING

- A.** See Part 2 of this Section.

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3.7 EQUIPMENT CONNECTIONS

- A. EMS Class II field wiring for all non-control device applications shall be installed under this Section of the Specification. This includes equipment such as VFDs, chillers, boilers, etc., which may have point types including status or alarm monitored from an equipment supplier Class C contact or analog control signals to equipment, etc.

END OF SECTION