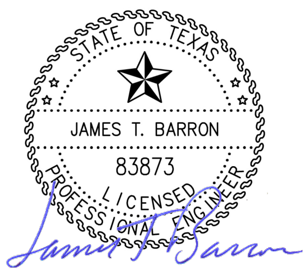
Replacement Generator Low Facility
Federal Correction Complex, Forrest City

Project Specifications

VOLUME 1 of 1



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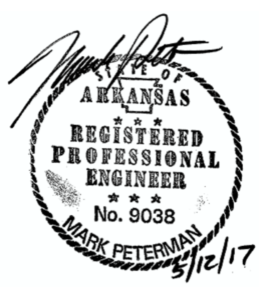

MEP Engineering:
B & H Engineers, Inc.

Civil Engineering:
Matkin Hoover Engineering & Surveying

Structural Engineering:
LA Fuess Partners, Inc.

May 12, 2017

VOLUME 1

SECTION 03 11 00
STRUCTURAL CONCRETE FORMWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Furnish, install and remove formwork for concrete.

1.2 REFERENCES

A. American Concrete Institute:

1. ACI 117, Specifications for Tolerances for Concrete Construction and Materials
2. ACI 301, Specifications for Structural Concrete
3. ACI 315, Detail and Detailing of Concrete Reinforcement
4. ACI 318, Building Code Requirements for Structural Concrete
5. ACI 347R, Guide to Formwork for Concrete

B. Concrete Reinforcing Steel Institute, CRSI Manual of Standard Practice

C. American Society for Testing Materials (ASTM)

1. ASTM C203, Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation
2. ASTM D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics
3. ASTM D1751, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

1.3 SUBMITTALS

A. Shop Drawings:

B. Construction Joints: Submit diagrams of construction joints.

C. Product Data:

1. Form release agent
2. Vapor retarder

1.4 DELIVERY, STORAGE AND HANDLING

A. Store materials off of the ground and protected from weather.

1. Prevent warpage, twisting and excessive moisture gain of wood materials.
2. Discard damaged or deformed materials.

B. Protect smooth faces of form liner materials from abrasion, denting or scarring during handling.

PART 2 - PRODUCTS

2.1 GENERAL

A. Design and construct forms to withstand stresses due to weight of fresh concrete, vibration during consolidation and loads of equipment and workmen.

B. Limit deflections of forms to provide smooth, straight surfaces without unsightly bulges and deformations.

2.2 MATERIALS

A. Wood forms for unexposed concrete surfaces: No. 2 Southern Yellow Pine or Douglas Fir dressed to uniform and smooth contact surfaces.

B. Wood forms for concrete surfaces exposed to view: Commercial Standard Douglas Fir concrete form plywood, moisture resistant, not less than 5 plies, and minimum thickness of 9/16 inch. Line forms with one of the following:

1. Plywood: Commercial Standard Douglas Fir, concrete form, exterior, 3 ply, not less 1/4 inch thick with one smooth face.
2. Fiberboard: Treated, hard pressed fiberboard, moisture resistant, not less than 3/16 inch thick with one smooth side.

2.3 COMPONENTS

A. Rustications and bevels: steel, polyvinyl chloride or milled and sealed white pine.

B. Corner chamfers: 3/4 inch white pine or pvc.

2.4 ACCESSORIES

A. Form ties: bolt rods or patented devices of sufficient strength to withstand pressure due to wet concrete (3000 lbs. minimum tensile strength); adjustable in length, and removable to a depth of at least 1 inch from the face of the concrete.

1. Ties for exposed concrete surfaces shall be equipped with plastic cones 5/8 inch in diameter.
2. Do not use wire ties, or makeshift ties that leave unsightly marks or depressions on the face of the concrete.

B. Form release agent:

1. Does not bond with, stain, or adversely affect concrete surfaces.
2. Meets acceptable air quality standards.

PART 3 - EXECUTION

3.1 DESIGN AND CONSTRUCTION

A. Design formwork for concrete elements to have correct dimension, shape, alignment, elevation, and position within the dimensional tolerances conforming to ACI 117. Reference ACI 347.

B. Design formwork to safely support vertical and lateral loads that might be applied until such loads can be supported by the concrete structure. Carry vertical and lateral loads to the ground by the formwork system or by in-place construction that has adequate strength.

C. Form sides of concrete elements unless specifically noted or shown otherwise on the Drawings.

1. Dimensional tolerances to conform to ACI 117.

2. Bulges and offsets and any condition of the formwork that would cause beam sides to become skewed or wider than void box bottom forms shall be repaired before placing concrete.

D. Construct forms to required shapes, lines and dimensions; provide necessary studs, walers, ties, centering, molds and supports.

1. Forms shall be sufficiently tight to prevent leakage of mortar.
2. Construct forms to be easily removable without damage to finished surfaces.
3. Forms shall not have unsightly marks or deformations on exposed faces.
4. Thoroughly clean forms of concrete laitance before re-use.
5. Provide clean-outs at the base of vertical forms for removal of foreign materials before placement of concrete.

E. Tying of forms: provide sufficient form ties to prevent bulging or collapse of forms under weight of wet concrete.

1. Place ties in a uniform and orderly pattern.
2. Lubricate ties to prevent bonding with concrete.

F. Special features: place in forms any wood strips, blocking, molding, and liners necessary to produce required shapes.

1. Attach feature strips to forms in a manner that will not leave unsightly marks on exposed concrete surfaces.
2. Coat wood strips, blocking and molding with form sealer.
3. Provide chamfer strips in corners of formwork.
4. Provide dove-tailed anchor slots coordinated with masonry.

G. Coatings:

1. Coat contact surfaces of wood forms with form release agent before each use and before placing reinforcement.
2. Apply form release agent per manufacturer's recommendations.
3. Do not allow excess release agent to accumulate in forms or to contact hardened concrete against which fresh concrete will be placed.
4. Remove release agent from reinforcement before placing concrete.

H. Construction joints:

1. Locate construction joints as shown on approved submittals.
   a. Locate construction joints in continuous footings and slabs approximately at midspan between spread footings.
   b. Construction joints shall be plumb and level. In order to avoid irregular lines at horizontal construction joints in exposed concrete faces, tack a continuous strip of dressed lumber, one inch thick, to inside of wall or grade beam form, with its lower edge at line of construction joint. About one hour after placing concrete in lower part of wall or grade beam, remove strip, level off irregularities which appear in joint line with wood float and remove any laitance present.
   c. Provide shear keys and waterstops as required in construction joints.

I. Earth forming or soil cast:

1. Excavated foundation element sides not required to be formed shall be as near vertical as possible, but not more than 3 inches wider than the required beam width at the base. Provide side forms where this condition cannot be maintained.

3.2 REMOVAL OF FORMS

A. Remove forms completely, unless specifically required otherwise.

B. Remove forms carefully to avoid damage to concrete surfaces.

C. Do not remove forms until concrete has adequately set.

1. Clamps and tie rods may be loosened after 24 hours following placement of concrete.
    a. Maintain sufficient ties to hold forms in place.
    b. Withdraw through-wall ties toward the inside (or unexposed) face of walls and beams.
    c. Prevent spalling during removal of ties.

2. Concrete strength tests may be used as evidence that concrete has adequately set for form removal.
    a. Minimum strength shall be 75% of design strength.

END OF SECTION

SECTION 03 20 00
CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Preparation of shop drawings
2. Fabrication and placement of reinforcing

1.2 REFERENCES

A. Codes and Specifications

1. American Concrete Institute:
   a. ACI 318, Building Code Requirements for Reinforced Concrete.
   b. ACI 315, Manual of Standard Practice for Detailing Reinforced Concrete Structures.

2. Concrete Reinforcing Steel Institute, CRSI, Manual of Standard Practice.
3. American Welding Society, AWS D1.4, "Structural Welding Code - Reinforcing Steel"
4. American Society for Testing Materials (ASTM)
   a. ASTM A1064, Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain, and Deformed, for Concrete.
   b. ASTM A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   c. ASTM A706, Standard Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement.
   d. ASTM A775, Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
   e. ASTM D3963, Standard Specification for Fabrication and Jobsite Handling of Epoxy Coated Steel Reinforcing Bars.
   f. ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

1.3 SUBMITTALS

A. Shop Drawings

1. Submit shop and installation drawings for review by Architect, including:
   a. Sizes and quantities of reinforcing
   b. Reinforcing lengths and details of bending
   c. Placement instructions
   d. Details and spacing of supports for reinforcing
   e. Reference Engineer's reinforcing designations
   f. Reproduce Engineer's notes regarding placement of reinforcing.

2. Review of Shop Drawings will be for reinforcing sizes, spacing, and general detail only, excluding quantities, lengths and fit of materials.
3. Reproductions of Contract Drawings shall not be used for shop drawings.

B. Quality Control Submittals

1. Submit certified copies of mill reports, evidencing compliance with requirements of Specifications.

2. Submit copies of laboratory testing and inspection reports.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in tagged bundles grouped as to reinforcing size and length.

B. Store reinforcing on skids off of the ground and stacked to permit drainage. Prevent build-up of rust and dirt on reinforcing. Protect reinforcing from contamination that would prevent bonding of concrete.

C. Do not bend, twist or warp reinforcing during handling.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcing Steel

1. Deformed bars: new billet steel conforming to ASTM A615 of required grades.
2. Welded wire reinforcement: conform to ASTM A1064.

2.2 MANUFACTURED UNITS

A. Full-tension sleeve bar splices: sleeve with ferrous filler capable of developing 125% of the yield strength of the required bar size.

1. Example product: Cadweld Rebar Splice C-Series by Erico Products

B. Compression sleeve splice: sleeve with ferrous filler capable of developing 100% of the ultimate compression strength of the required bar size.

1. For use where compression lap splices are not permitted.
2. Example product: Cadweld Rebar Splice Series C-16

C. Compression bar splice: bolted sleeve capable of developing 100% of the ultimate compression strength of the required bar size.

1. For use where compression lap splices are allowed.
2. Example product: Erico Speed Sleeve

D. Mechanical couplings: taper threaded hexagonal steel couplers conforming to ACI 318.

1. Provide end caps for future construction applications.
2. Example product: Lenton Rebar Splicing System by Erico Products.

2.3 ACCESSORIES

A. Reinforcing supports: comply with ACI 315, Chapter 5.

1. Provide concrete bricks or chairs with bearing plates where supports are in contact with soil or vapor barrier.
2. Provide continuous supports with spacers for slab reinforcing.

2.4 FABRICATION

A. Shop Fabrication

1. Cut reinforcing to required lengths
2. Bend reinforcing cold with suitable equipment. Do not heat or stretch material. Bend radii and extensions shall comply with ACI 318.
3. Do not use reinforcing with kinks or unrequired bends.
4. Do not re-straighten reinforcing bent more than 30 degrees.

B. Tolerances: comply with ACI 318.

C. Marking: mark reinforcing to correspond with shop drawings.

D. Bars shall be uncoated unless noted otherwise on Drawings.

2.5 SOURCE QUALITY CONTROL

A. Testing Laboratory Services

1. Inspect fabricating and bending procedures
2. Inspect fabricated materials

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean reinforcing of rust, mill scale, dirt, oil and grease.

B. Repair damaged epoxy coating with material conforming to Annex A1 of ASTM D3963. Apply in accordance with manufacturer's recommendations.

3.2 PLACEMENT

A. Place reinforcing of required sizes and quantities in proper position. Use sufficient supports and spacers to maintain position during placement of concrete.

1. Do not place reinforcing supports against exposed faces of footings.

B. Secure reinforcing in position with wire ties complying with ACI 318.

1. Clip or bend tails of tie wire away from exposed faces, do not leave tie wire within 1 1/2" of any exposed surface.

C. Concrete Cover: comply with ACI 318 and Project General Notes.

D. Tolerances

1. Top reinforcing in slabs and beams
   a. Members 8 inches deep or less: + 1/4 inch
   b. Members more than 8 inches but not over 2 feet deep: + 1/2 inch
   c. Members more than 2 feet deep: + one inch

2. Lengthwise of members: + 2 inches
3. Concrete cover to formed surfaces: + 1/4 inch
4. Minimum spacing between reinforcing bars: 1/4 inch

E. Support reinforcing in slabs-on-grade on bolsters or blocks. Do not lift reinforcing during concrete placement.

3.3 COLD BENDING OF BARS IN THE FIELD

A. Dowels connecting concrete of different pour sequences may be bent in the field to facilitate form placement and removal with the following conditions:

1. Maximum bar size is #4
2. Maximum angle of bend is 90 degrees
3. Bars may be bent and straightened one time only

3.4 FIELD QUALITY CONTROL

A. Testing Laboratory Services

1. Inspect reinforcing sizes, quantities and placement.
2. Inspect support and securement of reinforcing.
3. Inspect condition of reinforcing.

END OF SECTION

SECTION 03 30 13
CONCRETE FOOTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating and cleaning.
2. Placing concrete and reinforcing steel.
3. Furnish templates and place anchor bolts and dowels.

B. Products Installed, not Furnished Under This Section:

1. Reinforcing Steel
2. Structural Concrete

1.2 SUBMITTALS

A. Submit shop drawings of reinforcement, dowels and anchor bolts.

B. Submit a log of footings installed indicating the following:

1. Top of footing elevation.
2. Top of bearing strata elevation.
3. Bottom of footing elevation.
4. Concrete quantity.
5. Concrete fill placed under footing.

PART 2 - PRODUCTS - Not applicable (see related sections)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Excavating:

1. Excavate for footings of required size and depth (minimum).
2. Excavate to required minimum depth below finish grade or finish floor, or to required bearing strata.
3. Clean bottom of excavations of loose dirt, debris and loose material.
4. Where soft material is encountered, excavate to firm bearing.
5. Fill over-excavations with additional engineered fill material.

B. Tolerances:

1. Maximum lateral variation off of centerlines: 2 inches.
2. Footing size: not smaller than required sizes.
3. Top elevation: plus one inch, minus 1 inch.
4. Bottom (bearing) surface: level to within one vertical to ten horizontal.
5. Placement of anchor bolts: within 1/4 inch any direction.

C. Drainage and Pumping:

1. Maintain bearing surface of footing excavations in the optimal moisture range of engineered fill subgrade.
2. Remove accumulated water and ice and excavate to firm, dry surface.

D. Reinforcing and Anchor Bolts:

1. Tie reinforcing securely into cages or mats.
2. Support reinforcing above ground with special chairs or precast bolsters.
3. Secure reinforcing and anchor bolts in place, prevent shifting during placement of concrete.
4. Use templates to position anchor bolts accurately.

E. Concreting:

1. Do not place concrete into or through standing water or mud.
2. Do not place concrete on frozen subgrade.
3. Place concrete in one continuous operation for each footing.
4. Consolidate concrete by vibrating.

3.2 FIELD QUALITY CONTROL

A. Testing Laboratory Services:

1. Identify bearing strata
2. Inspect condition of bearing surface prior to placing concrete.
3. Check sizes and quantity of reinforcing bars, tying and securement.
4. Monitor placement and consolidation of concrete.
5. Maintain logs of footing installation to verify Contractor's log.

END OF SECTION

SECTION 03 31 00
STRUCTURAL CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Design of concrete mixes
2. Furnish and place cast-in-place concrete
3. Curing and finishing of concrete

1.2 REFERENCES

A. American Concrete Institute:

1. ACI 117, Standard Specifications for Tolerances for Concrete Construction and Materials.
2. ACI 211.1, Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete.
3. ACI 214, Recommended Practice for Evaluation of Strength Test Results of Concrete.
4. ACI 301, Specifications for Structural Concrete for Buildings.
5. ACI 302, Guide for Concrete Floor and Slab Construction.
6. ACI 304, Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.
7. ACI 305, Hot Weather Concreting.
8. ACI 306, Cold Weather Concreting.
9. ACI 318, Building Code Requirements for Structural Concrete.
10. SP15, Field Reference Manual, Specifications for Structural Concrete for Buildings with Selected ACI and ASTM References.

B. American Society for Testing and Materials:

1. ASTM C31, Standard Method of Making and Curing Concrete Test Specimens in the Field.
2. ASTM C33, Standard Specification for Concrete Aggregates.
3. ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
4. ASTM C42, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
5. ASTM C94, Standard Specification for Ready-Mixed Concrete.
6. ASTM C143, Standard Test Method for Slump of Portland Cement Concrete.
7. ASTM C150, Standard Specification for Portland Cement.
8. ASTM C156, Standard Test Method for Water Retention by Concrete Curing Materials.
9. ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.
10. ASTM C172, Standard Method of Sampling Fresh Concrete.
11. ASTM C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
12. ASTM C260, Standard Specification for Air- Entraining Admixtures for Concrete.
13. ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
14. ASTM C494, Standard Specification for Chemical Admixtures for Concrete.
15. ASTM C618, Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
16. ASTM C1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
17. ASTM C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.

18. ASTM E1155, Standard Test Method for Determining Floor Flatness and Levelness Using the "F Number" System (Inch-Pound) Units.
19. ASTM E1745, Standard Specification for Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs.

C. Corps of Engineers:

1. CRD-C13, Standard Specification for Air- Entraining Admixtures for Concrete.

D. Field Reference Manual: Contractor shall have available in field office a copy of ACI SP-15.

1.3 SUBMITTALS

A. Product Data: submit manufacturers data indicating product compliance for the following:

1. Admixtures
2. Curing compound
3. Curing and Sealing Compound
4. Waterstops

B. Material Certifications: submit certifications showing compliance for the following:

1. Fly ash.
2. Sieve analyses for structural concrete aggregates:

   a. Coarse aggregate.
   b. Fine aggregate.

C. Structural Concrete Mix Designs for each class of concrete

D. Concrete Delivery Tickets: Submit sample ready-mixed concrete delivery tickets in accordance with ASTM C94 for each class of concrete.

E. Construction Joints: submit drawings indicating proposed locations of construction joints.

1.4 QUALITY ASSURANCE

A. Batch Plant Qualifications - conform to the "Check List for Certification of Ready-Mixed Concrete Production Facilities" of the National Ready-Mixed Concrete Association.

1.5 DELIVERY, STORAGE AND HANDLING

A. Transporting: Ready-mixed concrete supplier shall have sufficient capacity and adequate facilities to provide continuous delivery at the rate required for continuous placement throughout any sequence of placement.

B. Storage of Materials

1. Store cement in weathertight buildings or bins which prevent intrusion of moisture or contaminants. Store different types of cement in separate facilities.
2. Stockpile aggregates to prevent segregation and contamination with other materials. Thaw frozen aggregates before use.
3. Sand shall be drained to a uniform moisture content before use.
4. Store admixtures securely to prevent contamination, evaporation, damage or temperature variation in excess of the range recommended by the manufacturer.

C. Delivery: Truck mixers, agitators and non-agitating units shall conform to the applicable requirements of ASTM C94, "Specification for Ready-Mixed Concrete".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Ardex Inc.

B. Dayton Superior

C. Euclid Chemical Company

D. W.R. Grace & Company

E. Spec Chem

F. Master Builders

G. W.R. Meadows

H. Sika Corporation

I. Sonneborn

2.2 MATERIALS

A. Portland cement: shall be Type I, II or III Portland Cement and meet the requirements of ASTM C150.

B. Fine aggregate: conform to applicable requirements of ASTM C33, natural bank or river sand, washed and screened, consisting of hard, durable, uncoated particles free of deleterious matter, and graded from coarse to fine to produce a minimum percentage of voids.

C. Coarse aggregate: conform to applicable requirements of ASTM C33, gravel or crushed stone, suitably processed, washed and screened; consisting of hard, durable particles without adherent coatings.

D. Water: shall be clear, potable, city water free of all substances which would be harmful to the concrete.

E. Fly Ash: conform to ASTM C618, carbon content not greater than 3% by volume.

F. Admixtures: Water-reducing, set-controlling admixtures shall conform to ASTM C494, Type A or D (F or G – High Range) and shall be used strictly in accordance with manufacturer's recommendations. Products as manufactured by The Euclid Chemical Company, Master Builders, W.R. Grace, or approved equal.

G. Air Entraining Admixtures: Shall conform to ASTM C260 and CRD C-13. Products as manufactured by The Euclid Chemical Company, Master Builders, W.R. Grace, or approved equal.

H. Calcium chloride thiocyanates or admixture containing more than 0.05 percent chloride ions shall not be permitted in concrete mixtures.

I. Admixtures containing chlorides shall not be used in concrete to be poured on metal floor deck, nor in post-tensioned concrete.

2.3 CURING AND FINISHING PRODUCTS

A. Liquid Curing Compound

1. Conform to ASTM C309, Types 1 and 1D, Class B, water based.
2. Meet federal and state VOC/AIM regulations.
3. Shall be dissipating resin type, which chemically breaks down after approximately eight (8) weeks.
4. Shall not inhibit bonding of flooring adhesives.
5. Shall not inhibit bond breaker, where applicable.
6. Sodium silicates prohibited.
7. Use on all interior slabs to receive subsequent floor coverings and parking structures.

B. Curing and Sealing Compounds:

1. Conform to ASTM C1315, Type 1, Class B.
2. Minimum 25 percent solids by volume.
3. Moisture loss shall be not more than 0.30 Kg/M2 when applied at 300 square feet per gallon.
4. Meet federal and state VOC/AIM regulations.

C. Evaporation Retardant:

1. Shall be a thin, continuous film which prevents rapid moisture loss from the concrete surface.
2. Use when concrete operations must be performed in direct sun, wind, or high temperatures.

D. Waterproof Paper:

1. Waterproof paper for curing concrete - 2 ply fiber-reinforced, asphaltic kraft paper, conform to ASTM C171.

E. Liquid Densifier / Sealer:

1. Shall be siliconate based sealer that penetrates concrete surfaces, increases abrasion resistance, and provides a “low sheen” surface.
2. Clear, non-yellowing, fast curing, chemically neutral, without oils, fillers, extenders and stabilizers.
3. Shall not inhibit bonding of flooring adhesives.
4. Shall not inhibit bond breaker, where applicable.

F. Curing and finishing products and their application shall comply with applicable air-quality and environmental regulations.

2.4 MISCELLANEOUS PRODUCTS

A. Waterstops: shall be one of the following, or an approved equal, installed per manufacturer's recommendations:

1. Bulb type with minimum 3 inch ribbed extension into concrete each side of joint. One side shall be split for anchoring to formwork.

   a. Representative product: "Sealtight No. 6316", W.R. Meadows Co.

2. Self-sealing non-swelling preformed joint sealant.

   a. Representative product: "SF302 Synko-Flex Waterstop", Henry Company

3. Expanding preformed strip utilizing high sodium-bentonite content.

a. Representative product: "Volclay Waterstop-RX, Model RX101", American Colloid Company

B. Non-Shrink Grout: pre-mixed, non-shrinking, minimum compressive strength 5000 psi in 28 days, conform to U.S. Army Corp of Engineers Specification No. CRD-C621.

1. Grout exposed to view shall be non-oxidizing

2.5 CONCRETE MIXES

A. General: Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, water, and admixtures where applicable. Design concrete mixes to be workable and appropriate for each application, to bond readily to reinforcement, without segregation or the formation of excessive free water on surfaces.

B. Selection of Proportions

1. Determine proportions of ingredients in accordance with ACI 318, Chapter 5 to provide required strength, slump, resistance to weathering, placeability, durability and surface hardness for each class of concrete.
2. Provide admixtures as required or appropriate to enhance workability, control set or improve strength.

C. Required Average Strength for Mix Design:

1. Where suitable strength test records for the concrete production facility are available, design strength may be based on the standard deviation in accordance with ACI 318.
2. Where strength test records are not available, design strength shall be based on the following:
3.
4. Specified Strength   Required Average Strength
5. F'c - psi   F'cr - psi
6. ----------------------   -------------------------
7. F'c <3000   F'c + 1000
8. 3000 <= F'c <=5000   F'c + 1200
9. F'c > 5000   1.10 F'c + 700
10.

D. Documentation of Average Strength: provide evidence of average strength for each class of concrete in accordance with ACI 318 by field strength tests, strength test records or trial mixtures.

E. Concrete Mix Designs: submit mix designs for each class of concrete.

1. Indicate the following for each mix design:

a. Class designation.
b. Proportions of cement, fine and coarse aggregates, and water.
c. Water-cement ratio, design strength, slump, and air content.
d. Type of cement and aggregates.
e. Type and dosage of admixtures.

2. Mix designs shall be adjusted as required by weather and jobsite conditions to maintain specified strengths throughout the course of the work without additional cost to the Owner.
3. As strength data becomes available during the progress of the work, mix designs may be adjusted in accordance with ACI 318.
4. Minimum Cement Content: Cement content shall not be less than 320 pounds per cubic yard.

5. Fly ash content shall not exceed 25 percent of total cementitious material content by weight.

F. Strength Gain: design concrete mixes to obtain required strengths in 28 days or less from date of placement.

2.6 PRODUCTION OF CONCRETE

A. Do not mix concrete for placement in the work until mix designs and corresponding strength tests reflect that each proposed mix will develop strengths required and mix designs have been reviewed for compliance.

B. Batching and Mixing:

1. Batch and mix ready-mixed concrete in accordance with ASTM C94.
2. Batch site-mixed concrete with scales accurate to within 0.4 percent of their total capacities. Operation of batching equipment shall consistently measure ingredients within 1 percent for concrete and water, 2 percent for aggregates and 3 percent for admixtures. Mixing of site-batched concrete shall be in accordance ACI 301.

C. Admixtures: Air-entraining admixtures and other chemical admixtures shall be charged into mixer as solutions and shall be accurately measured by means of a mechanical dispenser. The liquid shall be considered as part of mixing water.

2.7 SOURCE QUALITY CONTROL

A. Laboratory Inspection

1. Verify required plant certifications
2. Inspect batching equipment periodically
3. Inspect batching and loading of transit-mix trucks at the start of each day of production.

B. Materials Testing

1. Sieve analysis of aggregates

PART 3 - EXECUTION

3.1 PREPARATION

A. Do not begin delivery of concrete materials until formwork, reinforcement, and all items required to be embedded in the concrete are complete, properly positioned and secured in place.

1. Remove snow, ice, debris and excessive water from forms.
2. Pre-wet soil and sand subgrades and surfaces of precast concrete to receive fresh concrete.
3. Position and secure expansion joint materials, anchors, waterstops, screeds, control joint forms, and expansion caps on slip-dowels.
4. Remove hardened concrete and foreign materials from the inner surfaces of conveying equipment, formwork and reinforcing.

B. Prepare and have ready in good working condition chutes, tremies, pumps, buggies, vibrators and all other equipment necessary for the orderly and continuous placement of concrete.

3.2 INSTALLATION

A. Conveying:

1. Prevent separation, segregation and loss of ingredients.
2. Convey concrete from mixer to place of final deposit as rapidly as possible.
3. Take special precautions with belt conveyors to prevent segregation of ingredients, drying and rise in temperature during conveying.
4. Pumps or pneumatic equipment shall have adequate pumping capacity. Slump loss due to pumping shall not exceed 2 inches. Do not convey concrete through pipes made of aluminum or aluminum alloy.
5. Thoroughly clean conveying equipment at the end of each placement sequence.

B. Depositing:

1. Place concrete continuously in horizontal layers not more than 12 inches deep. Exercise care to avoid seams or weakened planes within the concrete. Deposit concrete into (not away from) previously deposited concrete.
2. Do not place fresh concrete on partially hardened or contaminated concrete.
3. Do not place concrete which has partially set.
4. Exercise care to avoid splashing forms and reinforcing with concrete.
5. Place concrete in forms as near as possible to its final position, do not transport in the forms with vibrators or screeds.
6. Do not drop concrete directly into standing water, use a tremie with the outlet near the bottom of the place of deposit.
7. Use tremies, chutes or hoppers to place concrete where a vertical drop greater than 5 feet is required.
8. Do not place concrete when slump tests indicate plasticity that is greater than required limits.
9. Continuously monitor the condition of void box forms during placement of concrete. Avoid piling concrete on void forms. Replace void boxes that partially or wholly collapse under weight of concrete.

C. Consolidating:

1. As soon as concrete is deposited, thoroughly agitate by means of mechanical vibrators and suitable hand tools, to work the mixture well into all parts and corners of the forms, and entirely around the reinforcement and inserts. Consolidation of concrete shall be in accordance with ACI 309.
2. Mechanical vibrators shall have minimum frequency of 7000 revolutions per minute.
3. Do not over-vibrate concrete or use vibrators to transport concrete within forms. Insert vibrators vertically at frequent intervals, do not drag vibrators through concrete.
4. Do not insert vibrators into lower courses that have begun to set.
5. Maintain spare vibrators on the job site during all concrete placing operations.

D. Bonding:

1. Before depositing new concrete on or against previously deposited concrete which has partially or entirely set, thoroughly clean and roughen surfaces to receive fresh concrete.
2. Re-tighten and thoroughly clean forms and reinforcement.
3. Apply 1 to 2 inches of grout to concrete surfaces. Grout shall be of identical mix to concrete without coarse aggregate.
4. Deposit new concrete before grout attains initial set.

3.3 APPLICATION

A. Construction Joints

1. Each unit of structure shall be monolithic in construction except where specifically required to be otherwise.

2. Where required, construction joints shall be located near the midspan of slabs or continuous footings.
3. Construction joints shall be located only where required or shown on accepted submittals.

B. Weather Conditions:

1. Cold Weather: Conform to ACI 306
2. Hot Weather: Temperature of concrete delivered at job site shall not exceed 95 degrees F. Add ice to mixing water as required to control temperature of mixture.

   a. Conform to ACI 305.
   b. Make provisions for windbreaks, shading, fog spraying, sprinkling or wet cover when necessary.
   c. Use evaporation retarders, and finishing aids when necessary to achieve sound, durable surfaces.

C. Floor Flatness and Levelness Tolerances:

1. General: Tolerances in floor slab elevation shall not exceed the following:

   a. For slabs on grade: plus or minus 1/4 inch in 10 ft in any direction. Laser leveling of floor slab surface may be used.

3.4 FINISHING EXPOSED CONCRETE SURFACES

A. General

1. Comply with ACI 302.
2. Double screed slabs at required elevations.
3. Apply finishing products and cure in accordance with manufacturers' recommendations.

B. Slab Surfaces

1. Float Finish

   a. Locations
      1) Initial finish for all horizontal surfaces

   b. Method - after concrete has been placed, consolidated, struck off and leveled begin first float. Check levelness and correct as required during first float. Second float shall produce a uniform and true surface with a sandy texture.

2. Trowel Finish

   a. Locations - all floor slabs except where specifically required otherwise.
   b. Method - First apply float finish, then power-trowel and finally hand trowel to produce a dense, smooth surface free of trowel marks and blemishes, and uniform in texture and appearance. Do not add cement slurry or water to surface during finishing. Grind high spots and fill low spots with specified materials.

C. Saw-Cutting Concrete Slabs-on-Grade

1. Saw joints as soon as possible after finishing, but only after concrete is hard enough. Concrete is hard enough when saw blade does not dislodge aggregate and when edges of sawcut do not ravel.
2. Joints shall be a as shown on the structural drawings.

3. Formed strips may be used in lieu of saw-cutting in the same locations and to equal depth as sawn joints.

D. Formed Surfaces

1. General: Holes resulting from the removal of bolts or tie rods shall be solidly filled with cement grout. Fill holes passing entirely through concrete members from the inside face with a plunger-type grease gun or other device that will force the mortar through to the outside face.
2. Rough Form Finish: for surfaces not exposed to view

   a. Remove fins exceeding 1/4th inch in height, and grind bulges that interfere with other trades.
   b. Fill holes and honeycombs.

3. Rubbed Finish

   a. Apply finish as soon as possible after casting concrete, no later than the day following form removal.
   b. Wet surface and rub with carborundum brick or other abrasive to produce uniform color and texture.
   c. Form tie holes and honeycombs shall be patched and dressed to match color and texture of surrounding concrete.

3.5 CURING AND PROTECTION

A. General: Beginning immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures and mechanical damage.

B. Preservation of Moisture: protect surfaces not in contact with forms from moisture loss with one of the following methods immediately after finishing and continuing for a period of at least 7 days:

1. Ponding or continuous sprinkling
2. Application of absorptive mats or fabric kept continuously wet.
3. Application of sand kept continuously wet.
4. Continuous application of steam or mist.
5. Application of waterproof sheet materials.
6. Application of curing compound in conformance with ASTM C309, "Specification for Liquid Membrane-Forming Compounds for Curing Concrete". Apply curing compounds in accordance with manufacturer's recommendations. Do not use curing compound on any surface against which additional concrete is to be placed or other material is to be bonded unless it is proven that the compound will not inhibit bonding, or positive measures are taken to completely remove the compound from areas to received bonded materials.

C. Protect surfaces cast against forms from moisture loss by keeping forms wet until removed. After form removal, protect exposed surfaces by one of the methods specified.

D. Curing shall be continued for a period of 7 days for Type I cement, or 3 days for Type III cement, or until tests indicate that the concrete has attained 70 percent of required strength.

3.6 FIELD QUALITY CONTROL

A. Laboratory Testing and Inspection

1. Concrete Compression Testing: Secure composite samples in accordance with ASTM C172. Samples for strength tests of each mix design placed each day shall be take not less than once a daily, nor less than once for each 150 cubic yards of concrete, nor less than once for each 5,000 square feet of surface area for slabs or walls. Mold and cure specimens from each sample in accordance with ASTM C31. Test concrete specimens in accordance with ASTM C39. A single strength test shall consist of one of the following:

   a. Four (4) 6"x12" cylinders: one cylinder tested at 7 days, two cylinders tested at 28 days, one cylinder held in reserve if needed.
   b. Five (5) 4"x8" cylinders: one cylinder tested at 7 days, three cylinders tested at 28 days, one cylinder held in reserve if needed.

2. Determine slump for each strength test and whenever consistency of concrete appears to vary, in accordance with ASTM C143. Ready mix trucks with Verifi Slump Management System, or approved equal, is permitted.
3. Determine total air content of normal-weight concrete sample for each strength test in accordance with ASTM C231.
4. Determine temperature of concrete sample for each strength test.
5. Inspection and Monitoring:

   a. Inspect concrete mixing and loading of transit-mix trucks at plant.
   b. Monitor addition of water to concrete at job site and length of time concrete is allowed to remain in truck during pour.
   c. Certify each delivery ticket indicating class of concrete delivered (or poured), amount of water added and time at which cement and aggregate were discharged into truck, and time at which concrete was discharged from truck.

B. Contractor's Responsibilities

1. Furnish necessary labor to assist testing agency in obtaining and handling samples at job-site.
2. Advise testing agency in advance of operations to allow for assignment of testing personnel and testing.
3. Provide and maintain for use of testing agency adequate facilities for proper curing of concrete test specimens on project site in accordance with ASTM C31.

C. Evaluation and Acceptance:

1. Strength level of a given class of concrete will be considered satisfactory if each of the following requirements are met for that class of concrete (strength test is the average of the strength of two 6x12 inch cylinders or three 4x8 inch cylinders made from the same sample of concrete at tested at 28 days or as determined by the engineer):

   a. Average of any three consecutive strength test results equal or exceed specified strength.
   b. No strength test result falls below the specified strength by more than 500 psi when the specified strength is 5,000 psi or less, or by more than 10% of the specified strength when the specified strength is greater than 5,000 psi.

2. Concrete strength tests made and tested by testing laboratory shall be sole criteria of concrete strength unless in-situ tests are made in accordance with Building Code by a qualified independent testing laboratory. Concrete for which strength tests do not meet criteria for acceptance shall be considered inadequate until proven otherwise.
3. Where strength tests of concrete fail to meet criteria specified herein, the Architect shall be sole judge of structural adequacy of concrete.

a. Burden of proof of structural adequacy shall be responsibility of Contractor. Strength evaluation shall conform to requirements of ACI 318, Chapters 5 and 20.

b. If, in the opinion of the Architect, strength evaluation testing indicates that structure is of inadequate strength, those portions of structure in question shall be repaired or removed and replaced as directed by Architect at no additional expense to Owner.

c. If strength tests fall below specified strength, but not so low as to cause concern for structural adequacy, the Architect may request improved conditions of curing or modification of design mixes to improve strength.

3.7 CLEANING AND REPAIR

A. Upon completion of the work, remove forms, equipment, protective coverings and any rubbish resulting therefrom from the premises. Finished concrete surfaces shall be left in a clean condition, satisfactory to the Owner. After sweeping with an ordinary broom and removing mortar, concrete droppings, loose dirt, and mud, wash concrete floors and platforms with soapsuds and scrub with a steel fiber brush. Mop up the suds and flush the surfaces with clean water. Provide adequate measures during scrubbing, mopping, and flushing operations to keep excessive or injurious amounts of water off resilient tile floors. Any damage occasioned to such floors by or on account of such operations shall be promptly, effectively and satisfactorily repaired.

B. Remove all concrete not required by the Drawings caused by overpour, bulging or collapse of forms or error in form construction.

END OF SECTION

SECTION 23 05 17
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. Metraflex Company (The).
3. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

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

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Revise paragraph below to suit Project and insert description of firestopping sealant.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
    b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

    b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

    b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
    b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
    b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION

SECTION 23 05 18
ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

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

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

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

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

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

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

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

PART 1 - GENERAL

1.1 SUMMARY

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

B. Related Sections include the following:

1. Division 23 Section "Vibration Controls for HVAC Piping and Equipment" for vibration isolation restraint devices.

1.2 DEFINITIONS

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

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

1.3 SUBMITTALS

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

B. Shop Drawings: Provide shop drawings for each location required for multiple piping supports and trapeze hangers. Provide manufacturer's catalog data including load capacity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers:

a. AAA Technology and Specialties Co., Inc.
b. B-Line Systems, Inc.
c. Grinnell Corp.
d. National Pipe Hanger Corp.
e. PHD Manufacturing, Inc.

2. Channel Support Systems:

a. B-Line Systems, Inc.
b. Grinnell Corp.; Power-Strut Unit.
c. National Pipe Hanger Corp.
d. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.

b. Michigan Hanger Co., Inc.
c. PHS Industries, Inc.
d. Pipe Shields, Inc.

2.2 MANUFACTURED UNITS

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

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard painted or galvanized finish.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
5. Insert Length: Extend 2 inches beyond sheet metal shield.

2.3 MISCELLANEOUS MATERIALS

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

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

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.

5. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
6. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
7. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-Type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
10. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
11. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
12. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
13. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
14. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

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

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

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.

7. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
8. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
9. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.

10. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

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

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

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

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

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

H. Insulated Piping: Comply with the following:

1. Install MSS SP-58, Type 39 protection saddles. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

2. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

3. Pipes NPS 8 and Larger: Include wood inserts.
4. Insert Material: Length at least as long as protective shield.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

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

3.4 METAL FABRICATION

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

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

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

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

3.5 ADJUSTING

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

3.6 PAINTING

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

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

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

END OF SECTION

SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 90 MPH.
2. Building Classification Category: II.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: B.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.

   a. Component Importance Factor: 1.0.
   b. Component Response Modification Factor: 1.5.
   c. Component Amplification Factor: 1.0.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

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

   a. Isolation Technology, Inc.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

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

   a. Isolation Technology, Inc.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

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

a. Isolation Technology, Inc.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

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

a. Isolation Technology, Inc.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

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

a. Isolation Technology, Inc.

b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Top housing with threaded mounting holes and internal leveling device.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint.

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

   a. Isolation Technology, Inc.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Top plate with elastomeric pad.
   c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

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

   a. Isolation Technology, Inc.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

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

    a. Isolation Technology, Inc.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

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

    a. Isolation Technology, Inc.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

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

    a. Isolation Technology, Inc.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with 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.

2.15 RESTRAINT CABLES

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

1. Kinetics Noise Control, Inc.

2. Loos & Co., Inc.
3. Mason Industries, Inc.

B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES

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

1. B-Line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc

B. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

C. 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.

D. 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.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

F. Mechanical Anchor Bolts: 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 required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 31 00 "Structural Concrete."

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

C. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

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. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the 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. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 23 21 13 "Hydronic Piping" for piping flexible connections.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

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

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

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

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:
1. Equipment nameplates.
2. Equipment markers.
3. Access panel and door markers.
4. Pipe markers.
5. Stencils.
6. Valve tags.
7. Valve schedules.
8. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

   a. Manufacturer, product name, model number, and serial number.
   b. Capacity, operating and power characteristics, and essential data.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2. Fabricate in sizes required for message

1. Terminology: Match schedules as closely as possible.
2. Data:

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

3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
4. Fasteners: Self-tapping, stainless-steel screws.

C. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

2.3 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.

1. Stencil Material: Metal or fiberboard.
2. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel, black, unless otherwise indicated. Paint may be in pressurized spray-can form.

3. Identification Paint: Exterior, alkyd enamel or acrylic enamel in colors according to ASME A13.1, unless otherwise indicated.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect or Engineer. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch- thick brass or aluminum.
2. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

2.5 VALVE SCHEDULES

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

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.6 WARNING TAGS

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

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

2.7 TAG IDENTIFICATION SCHEME FOR LOCATING HIDDEN COMPONENTS

A. Tag system to allow easy identification of the location of components and equipment that are not visible from the finished space and are accessible from the ceiling grid. Provide laminated, printed tags with pin back to be fastened flush with acoustical ceiling. The pin fasteners shall be manually removable without the use of tools and shall not separate from the ceiling panels when the panels are dropped from ceiling height. Tag shall be white background with black letters 3/8” high, each tag bearing the equipment tag. Concealed equipment to be tagged shall include but not limited to the following:

1. Exhaust fans.
2. VAV terminal units.
3. Hot water isolation valves.
4. Ductless split-system air-handling units.
5. Heat pumps.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
3. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
4. Fans, blowers, primary balancing dampers, and mixing boxes.
5. Packaged HVAC central-station and zone-type units.

B. Install equipment markers with mechanical fasteners on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

    a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
    b. Fire department hose valves and hose stations.
    c. Meters, gages, thermometers, and similar units.
    d. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
    e. Pumps, compressors, chillers, condensers, and similar motor-driven units.
    f. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
    g. Fans, blowers, primary balancing dampers, and mixing boxes.
    h. Packaged HVAC central-station and zone-type units.
    i. Tanks and pressure vessels.
    j. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Stenciled Equipment Marker Option: Stenciled markers may be provided instead of laminated-plastic equipment markers, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

D. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
2. Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.

B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers with painted, color-coded bands or rectangles complying with ASME A13.1 on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size, shape, and color:

   a. 1-1/2 inches, round, natural color.

3.5 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.6 WARNING-TAG INSTALLATION

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

3.7 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.8 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION

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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

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

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

1.3 ACTION SUBMITTALS

1.4 INFORMATIONAL SUBMITTALS

A. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

B. Certified TAB reports.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC, NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC, NEBB or TABB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

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

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

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

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

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

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

I. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

J. Examine operating safety interlocks and controls on HVAC equipment.

K. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures for balancing the systems.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Clean filters are installed.
b. Fans are operating, free of vibration, and rotating in correct direction.
c. Automatic temperature-control systems are operational.
d. Ceilings are installed.
e. Windows and doors are installed.
f. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation," and Section 23 07 19 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

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

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

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

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

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.

c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Owner for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

3.6 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.7 FINAL REPORT

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

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

B. Final Report Contents: In addition to certified field-report data, include the following:

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

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

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings including settings and percentage of maximum pitch diameter.
    e. Settings for supply-air, static-pressure controller.
    f. Other system operating conditions that affect performance.

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

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

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

3. Test Data (Indicated and Actual Values):

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Outdoor airflow in cfm.
   g. Return airflow in cfm.
   h. Outdoor-air damper position.
   i. Return-air damper position.

E. Apparatus-Coil Test Reports:

1. Coil Data:

   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft..
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Refrigerant expansion valve and refrigerant types.
   i. Refrigerant suction pressure in psig.
   j. Refrigerant suction temperature in deg F.

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

1. Fan Data:

   a. System identification.
   b. Location.

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

2. Motor Data:

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

3. Test Data (Indicated and Actual Values):

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

G. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

3.8 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner.

B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.9 ADDITIONAL TESTS

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

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

END OF SECTION

SECTION 23 07 13
DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.

B. Related Sections:

1. Section 23 07 19 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

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

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

D. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. CertainTeed Corporation.
   b. Johns Manville; a Berkshire Hathaway company.
   c. Knauf Insulation.
   d. Owens Corning.

2. CertainTeed Corporation, Johns Manville; a Berkshire Hathaway Company, Knauf Insulation, Owens Corning.

E. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. CertainTeed Corporation.
   b. Johns Manville; a Berkshire Hathaway company.
   c. Knauf Insulation.
   d. Manson Insulation Inc.

2.2 ADHESIVES

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

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

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

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

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

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

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

2.3 MASTICS

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

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

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FACTORY-APPLIED JACKETS

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

1. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6 TAPES

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

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

a. Avery Dennison Corporation, Specialty Tapes Division.
b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

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

a. Avery Dennison Corporation, Specialty Tapes Division.
b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.7 SECUREMENTS

A. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

C. Wire: 0.062-inch soft-annealed, galvanized steel.

2.8 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

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

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

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

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

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

3.3 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by

removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.4 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

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

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.6 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.

B. Items Not Insulated:

1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

3.7 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed or Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 3-lb/cu. ft. nominal density.

B. Concealed or Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 3-lb/cu. ft. nominal density.

C. Concealed or Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 3-lb/cu. ft. nominal density.

D. Concealed or Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 3-lb/cu. ft. nominal density.

E. Louvers Insulation: Rigid Mineral-fiber board, 2 inches thick and 3-lb/cu. ft. nominal density.

END OF SECTION

SECTION 23 07 19
HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

1. Section 23 07 13 "Duct Insulation."

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

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

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

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

a. Aeroflex USA, Inc.
b. Armacell, LLC.

2.2 ADHESIVES

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

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

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

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. Foster Brand; H. B. Fuller Construction Products.

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

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

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

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

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

2.3 MASTICS

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

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

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

1. Foster Brand; H.B. Fuller Construction Products, Knauf Insulation, Vimasco Corporation.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

2.4 SEALANTS

A. Joint Sealants:

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

a. Childers Brand; H. B. Fuller Construction Products.

b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

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

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 FIELD-APPLIED JACKETS

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

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

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

a. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. Proto Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White .
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

2.6 TAPES

A. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.
6. Tensile Strength: 34 lbf/inch in width.

2.7 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with closed seal.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. ITW Insulation Systems; Illinois Tool Works, Inc.

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

C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

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

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

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

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

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

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

3.3 PENETRATIONS

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

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

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

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

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

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

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies.

3.4 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves,

insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

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

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

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

3.7 FINISHES

A. Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

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

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

D. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping: Flexible elastomeric, 1 inch thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing: Flexible elastomeric, 1 inch thick.

C. Condensate and Equipment Drain Water: Flexible elastomeric, 1 inch thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping: Insulation shall be the following:

1. Flexible Elastomeric: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be the following:

1. Flexible Elastomeric: 2 inches thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC 30 mils thick.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

1. Aluminum, Smooth : 0.024 inch thick.

C. Piping, Exposed:

1. PVC: 30 mils thick.

3.14 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

SECTION 23 09 23.12
CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

B. Related Requirements:

1. Section 23 09 93.11 "Sequence of Operations for HVAC DDC".

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Selection Criteria:

1. Control dampers shall be suitable for operation at following conditions:

   a. Exhaust Air: 100 F.

2. Fail positions unless otherwise indicated:

   a. Exhaust Air: Last position.

3. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Steel Flat Blades:

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

    a. Ruskin.
    b. Nailor.
    c. Acme.

2. Performance:

    a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. against 1-in. wg differential static pressure.
    b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
    c. Velocity: Up to 1500 fpm.
    d. Temperature: Minus 25 to plus 180 deg F.
    e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg.
    f. Damper shall have AMCA seal for both air leakage and air performance.

3. Construction:

    a. Frame:

        1) Material: Galvanized or stainless steel,0.06 inch thick.
        2) Hat-shaped channel with integral flanges.
        3) Width not less than 5 inches.

    b. Blades:

        1) Flat blades with multiple grooves positioned axially for reinforcement.
        2) Parallel or opposed blade configuration as required by application.
        3) Material: Galvanized steel, 0.06 inch thick.
        4) Width not to exceed 6 inches.
        5) Length as required by close-off pressure, not to exceed 48 inches.

    c. Seals:

        1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
        2) Jambs: Stainless steel, compression type.

    d. Axles: 0.5-inch- diameter stainless steel, mechanically attached to blades.
    e. Bearings:

        1) Molded-synthetic sleeve, mounted in frame.
        2) Where blade axles are installed in vertical position, provide thrust bearings.

    f. Linkage:

1) Concealed in frame.
2) Constructed of stainless steel.
3) Hardware: Stainless steel.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions: As indicated below:

1. Exhaust Air: Last position.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. See Drawings
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

G. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

1. Rectangular Exhaust Air Duct Applications with SMACNA Construction Class A and Velocities to 1500 FPM: Rectangular dampers with aluminum flat blades.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

C. Seal penetrations made in fire-rated and acoustically rated assemblies.

D. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 23 33 00 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

G. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

H. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

I. Install engraved phenolic nameplate with damper identification on damper.

3.5 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION

SECTION 23 09 93.11
SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

1.2 DEFINITIONS

A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).

B. Binary Output: On/off output signal or contact closure.

C. DDC: Direct digital control.

D. Digital Output: Data output that must be interpreted digitally.

E. AHU: Air Handling Unit.

1.3 ACTION SUBMITTALS

A. Product Data:

1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

B. Shop Drawings:

1. Riser diagrams showing control network layout, communication protocol, and wire types.
2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.4 SEQUENCE OF OPERATION - SINGLE ZONE PACKAGED DX ROOFTOP UNITS AND SPLIT SYSTEMS (ALL SIZES)

A. A standalone programmable thermostat shall be provided for each unit by the unit manufacturer. The thermostat shall be a Honeywell 6000 or equal.

B. Motorized outside-air dampers shall be in the open position when the supply-air fan is energized and shall be closed when the supply-air fan is off. The open position shall be adjusted to provide the outside airflow specified in the equipment schedules on the Drawings.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 23 11 13
FACILITY FUEL-OIL PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fuel-oil pipes, tubes, and fittings.
2. Piping specialties.
3. Manual fuel-oil shutoff valves.
4. Specialty valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Pipe Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.

B. Fuel-Oil Valves: Comply with UL 842 and have service mark initials "WOG" permanently marked on valve body.

C. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil piping.

2.2 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3-psig fuel-oil supply pressure at oil-fired appliances.

2.3 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
    e. Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.4 PIPING SPECIALTIES

A. Metallic Flexible Connectors:

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

    a. Flexicraft Industries.
    b. Metraflex Company (The).
    c. Unaflex.

2. Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
3. Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
4. Minimum Operating Pressure: 150 psig.
5. End Connections: Socket, flanged, or threaded end to match connected piping.
6. Maximum Length: 30 inches
7. Swivel end, 50-psig maximum operating pressure.
8. Factory-furnished anode for connection to cathodic protection.

B. Nonmetallic Flexible Connectors:

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

    a. American Flexible Hose Co., Inc.
    b. Flexicraft Industries.
    c. Tru-Flex Metal Hose Corp.

2. Listed and labeled for underground applications by an NRTL acceptable to authorities having jurisdiction.
3. PFTE bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
4. Minimum Operating Pressure: 150 psig.
5. End Connections: Socket, flanged, or threaded end to match connected piping.
6. Maximum Length: 30 inches

7. Swivel end, 50-psig maximum operating pressure.
8. Factory-furnished anode.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

F. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

2.5 JOINING MATERIALS

A. Joint Compound and Tape for Threaded Joints: Suitable for fuel oil.

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

2.6 SPECIALTY VALVES

A. Pressure Relief Valves:

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

a. Anderson Greenwood; Pentair, Ltd.
b. Fulflo Specialties, Inc.

c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: Brass, bronze, or cast steel.
4. Springs: Stainless steel, interchangeable.
5. Seat and Seal: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Maximum Inlet Pressure: 150 psig.
9. Relief Pressure Setting: 60 psig.

B. Oil Safety Valves:

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

   a. Anderson Greenwood; Pentair, Ltd.
   b. Fulflo Specialties, Inc.
   c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
   d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: Brass, bronze, or cast steel.
4. Springs: Stainless steel.
5. Seat and Diaphragm: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Manual override port.
9. Maximum Inlet Pressure: 60 psig.
10. Maximum Outlet Pressure: 3 psig.

C. Emergency Shutoff Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. EMCO Wheaton.
   b. Franklin Fueling Systems.
   c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.

2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Double poppet valve.
4. Body: ASTM A 126, cast iron.
5. Disk: FPM.
6. Poppet Spring: Stainless steel.
7. Stem: Plated brass.
8. O-Ring: FPM.
9. Packing Nut: PTFE-coated brass.
10. Fusible link to close valve at 165 deg F.
11. Thermal relief to vent line pressure buildup due to fire.
12. Air test port.
13. Maximum Operating Pressure: 0.5 psig.

2.7 MECHANICAL LEAK-DETECTION VALVES

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

1. Franklin Fueling Systems.
2. Red Jacket Pumps.

B. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

C. Body: ASTM A 126, cast iron.

D. O-Rings: Elastomeric compatible with fuel oil.

E. Piston and Stem Seals: PTFE.

F. Stem and Spring: Stainless steel.

G. Piston Cylinder: Burnished brass.

H. Indicated Leak Rate: Maximum 3 gph at 10 psig.

I. Leak Indication: Reduced flow.

2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 PREPARATION

A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.2 OUTDOOR PIPING INSTALLATION

A. Install Underground Fuel-Oil Piping Buried:

1. Under Compacted Backfill: 18 inches below finished grade.
2. Under Asphalt 2 Inches Thick: 8 inches below bottom of asphalt.
3. Under 4 Inches of Reinforced Concrete in Areas Subject to Vehicle Traffic: 4 inches below bottom of concrete.
4. If fuel-oil piping is installed with less than 12 inches of cover to finished grade, install in containment piping.

B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
2. Replace pipe having damaged PE coating with new pipe.

C. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.

D. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.

E. Install metal pipes, fittings, valves, and flexible connectors at piping connections to AST and UST.

F. Install fittings for changes in direction in rigid pipe.

G. Install system components with pressure rating equal to or greater than system operating pressure.

3.3 INDOOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings at a height that allows sufficient space for ceiling panel removal.

F. Install piping free of sags and bends.

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

H. Comply with requirements for equipment specifications for roughing-in requirements.

I. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.

J. Prohibited Locations:

1. Do not install fuel-oil piping in or through HVAC ducts and plenums, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
2. Do not install fuel-oil piping in solid walls or partitions.

K. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

L. Connect branch piping from top or side of horizontal piping.

M. Install unions in pipes NPS 2 and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.

N. Do not use fuel-oil piping as grounding electrode.

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

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

3.4 VALVE INSTALLATION

A. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.

B. Install valves in accessible locations.

C. Install oil safety valves at inlet of each oil-fired appliance.

D. Install pressure relief valves in distribution piping between the supply and return lines.

E. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.

F. Install manual air vents at high points in fuel-oil piping.

G. Install emergency shutoff valves at dispensers.

3.5 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

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

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

D. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Bevel plain ends of steel pipe.
2. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support and equipment support materials and installation requirements are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

1. NPS 1-1/4 and Smaller: Maximum span, 84 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
4. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 1/2 inch.
5. NPS 3: Maximum span, 12 feet; minimum rod size, 1/2 inch.
6. NPS 4: Maximum span, 13 feet; minimum rod size, 5/8 inch.

C. Support vertical steel pipe at each floor and at spacing not greater than 15 feet.

3.7 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

B. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.

C. Connect piping to equipment with shutoff valve and union. Install union between valve and equipment.

D. Install flexible piping connectors at final connection to burners or oil-fired appliances.

3.8 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.

1. Text: In addition to identifying unit, distinguish between multiple units; inform operator of operational requirements; indicate safety and emergency precautions; and warn of hazards and improper operations.

B. Install detectable warning tape directly above fuel-oil piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.

1. Piping: Over underground fuel-oil distribution piping.

3.9 FIELD QUALITY CONTROL

A. Pressure Test Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:

1. Fuel-Oil Distribution Piping: Minimum 5 psig for minimum 30 minutes.
2. Suction Piping: Minimum 20-in. Hg for minimum 30 minutes.
3. Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig.

B. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Bleed air from fuel-oil piping using manual air vents.

E. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.10 OUTDOOR PIPING SCHEDULE

A. Underground Fuel-Oil-Tank Fill and Vent Piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground Fuel-Oil Piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.

3.11 INDOOR PIPING SCHEDULE

A. Aboveground Fuel-Oil Piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints

3.12 SHUTOFF VALVE SCHEDULE

A. Valves for Aboveground Distribution Piping:

1. Two-piece, full-port, bronze ball valves with bronze trim.

B. Valves in Branch Piping:

1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Condensate-drain piping.

1.2 ACTION SUBMITTALS

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

1. Copper pipe and fittings and joining materials.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Condensate-Drain Piping: 150 deg F (66 deg C).

2.2 COPPER TUBE AND FITTINGS

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

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. DWV Copper Tubing: ASTM B 306, Type DWV.

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

2.3 JOINING MATERIALS

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

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Condensate-Drain Piping: Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

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

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

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

L. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.

M. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.3 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/4 ((DN 32):)Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

3.4 PIPE JOINT CONSTRUCTION

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

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

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

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

E. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.5 FIELD QUALITY CONTROL

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

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

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty.

B. Shop Drawings:

1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig.
2. Suction Lines for Heat-Pump Applications: 225 psig.
3. Hot-Gas and Liquid Lines: 225 psig.

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

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

2.2 COPPER TUBE AND FITTINGS

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

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

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

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:

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

G. Moisture/Liquid Indicators:

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

    a. Danfoss Inc.
    b. Parker Hanifin Corporation.
    c. Sporlan Valve Company.

2. Body: Forged brass.
3. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
4. Indicator: Color coded to show moisture content in parts per million (ppm).
5. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
6. End Connections: Socket or flare.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

H. Replaceable-Core Filter Dryers: Comply with AHRI 730.

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

    a. Danfoss Inc.
    b. Parker Hanifin Corporation.
    c. Sporlan Valve Company.

2. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.

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

I. Permanent Filter Dryers: Comply with AHRI 730.

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

a. Danfoss Inc.
b. Emerson Climate Technologies.
c. Heldon Products; Henry Technologies.

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

2.3 REFRIGERANTS

A. ASHRAE 34, R-134a: Tetrafluoroethane.

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

a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.

B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

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

a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.

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

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

a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

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

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

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

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

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

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

3.4 VALVE AND SPECIALTY APPLICATIONS

A. Install a full-size, three-valve bypass around filter dryers.

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

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

C. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

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

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Compressor.

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

3.5 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Refer to Section 23 09 93.11 "Sequence of Operations for HVAC DDC" for sequence of operation.

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

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

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

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

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

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

R. Identify refrigerant piping and valves according to Section 23 05 53 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

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

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

3.7 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

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

D. Support multifloor vertical runs at least at each floor.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

a. Fill system with nitrogen to the required test pressure.
b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.9 SYSTEM CHARGING

A. Charge system using the following procedures:

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

3.10 ADJUSTING

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

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

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

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

B. Related Sections:

1. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

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

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.

1.5 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

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

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

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

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

2.2 ROUND DUCTS AND FITTINGS

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

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

   a. Ductmate Industries, Inc.
   b. McGill AirFlow LLC.
   c. Sheet Metal Connectors, Inc.

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

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

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

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

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

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

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

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

1. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 HANGERS AND SUPPORTS

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

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

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

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

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

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

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

H. Trapeze and Riser Supports:

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

2.6 SEISMIC-RESTRAINT DEVICES

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

1. B-line, an Eaton business.
2. Ductmate Industries, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized -steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

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

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

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

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

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

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

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

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

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

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.

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

3.2 INSTALLATION OF EXPOSED DUCTWORK

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

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

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

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

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

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

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

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

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

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

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

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

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

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.".

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

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

3.7 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.8 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :

a. Pressure Class: Positive 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval.

2. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: **3**.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A..
c. SMACNA Leakage Class for Rectangular: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative- 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular:12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 1-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

E. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

b. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

        1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
        2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
    c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

    a. Rectangular Main to Rectangular Branch: 45-degree entry.
    b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

    a. Velocity 1000 fpm or Lower: 90-degree tap.
    b. Velocity 1000 to 1500 fpm: Conical tap.

END OF SECTION

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flexible connectors.
2. Flexible ducts.
3. Duct accessory hardware.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Manual volume damper installations.
b. Control-damper installations.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

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

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

    a. Nailor Industries Inc.
    b. Pottorff.
    c. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

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

    a. Nailor Industries Inc.
    b. Pottorff.
    c. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.

4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
    e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
6. Blade Axles: Galvanized steel.
7. Bearings:
    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

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

2.4 TURNING VANES

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

1. Aero-Dyne Sound Control Co.
2. Duro Dyne Inc.
3. METALAIRE, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

2.5 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.6 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. JP Lamborn Co.
3. McGill AirFlow LLC.

B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

C. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

D. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.7 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

D. Set dampers to fully open position before testing, adjusting, and balancing.

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

F. Install flexible connectors to connect ducts to equipment.

G. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

H. Connect flexible ducts to metal ducts with liquid adhesive plus draw bands.

I. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect turning vanes for proper and secure installation.

END OF SECTION

SECTION 23 37 13.23
AIR REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fixed face registers and grilles.

B. Related Requirements:

1. Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 REGISTERS

A. Fixed Face Register:

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

a. Nailor Industries Inc.
b. Price Industries.
c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: Vertical spaced 3/4 inch apart.
5. Core Construction: Integral.
6. Frame: 1 inch wide.
7. Mounting: Countersunk screw.
8. Damper Type: Adjustable opposed blade.

2.2 GRILLES

A. Adjustable Blade Face Grille:

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

a. Nailor Industries Inc.
b. Price Industries.
c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, color selected by Architect.

4. Face Blade Arrangement: Vertical spaced 3/4 inch apart.
5. Core Construction: Integral.
6. Rear-Blade Arrangement: Horizontal spaced 1/2 inch apart.
7. Frame: 1 inch wide.
8. Mounting: Countersunk screw.
9. Accessories:

   a. Front-blade gang operator.

B. Fixed Face Grille:

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

   a. Nailor Industries Inc.
   b. Price Industries.
   c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: Vertical; spaced 3/4 inch apart.
5. Face Arrangement: Perforated core.
6. Core Construction: Integral.
7. Frame: 1 inch wide.
8. Mounting: Countersunk screw.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

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

END OF SECTION

SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.

1.6 QUALITY ASSURANCE

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

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

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

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

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

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts: One year(s) from date of Substantial Completion.
c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Carrier Corporation; a unit of United Technologies Corp.
2. Trane.

2.2 INDOOR UNITS (6 TONS OR MORE)

A. Floor-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.

a. Insulation: Faced, glass-fiber duct liner.

2. Condensate Drain Pans:

a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 2 inches deep.

b. Single-wall, galvanized-steel sheet.
c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end or both ends of pan.

1) Minimum Connection Size: NPS 1.

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.

4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan: Direct drive or belt drive, centrifugal.
6. Fan Motors:
   a. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   b. Enclosure Type: Totally enclosed, fan cooled.
   c. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   e. Mount unit-mounted disconnect switches on exterior of unit.

7. Air Filtration Section:

   a. General Requirements for Air Filtration Section:

      1) Comply with NFPA 90A.
      2) Minimum Arrestance: According to ASHRAE 52.1 and a MERV according to ASHRAE 52.2.
      3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

   b. Disposable Panel Filters:

      1) Factory-fabricated, viscous-coated, flat-panel type.
      2) Thickness: 2 inches.
      3) Merv according to ASHRAE 52.2: 5.
      4) Media: Interlaced glass fibers sprayed with nonflammable adhesive.
      5) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 OUTDOOR UNITS (6 TONS OR MORE)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

   a. Compressor Type: Scroll.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant Charge: R-407C R-410A.
   d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F.

7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

E. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

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

C. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03.
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

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

3.2 CONNECTIONS

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

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

C. Duct Connections: Duct installation requirements are specified in Section 23 31 13 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 23 33 00 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

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

C. Tests and Inspections:

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

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 26 00 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

1.2 REFERENCES

A. Standards - The design and construction of the facility shall comply with the following:

1. NFPA 70 - National Electric Code
2. NFPA 70E - Standard for Electrical Safety In The Workplace
3. NFPA 99 - Health Care Facilities
4. NFPA 101 - Life Safety Code
5. IEEE Standard 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants
6. IEEE Standard 142 - IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
7. IEEE Standard 241 - IEEE Recommended Practice for Electric Power Systems in Commercial Buildings
8. IEEE Standard 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
9. IEEE Standard 399 - IEEE Recommended Practice for Power System Analysis
10. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications
11. IEEE Standard 493 - IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems
12. IEEE Standard 602 - IEEE Recommended Practice for Electrical Systems for Health Care Facilities
13. IEEE Standard 739 - IEEE Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities
14. IEEE Standard 1100 - IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
15. American Correctional Association (ACA) Standards for Adult Correctional Institutions, latest edition and supplements
16. Code of Federal Regulations 10-CFR-435 and 10-CFR-436. Copies of the CFR are available from the Superintendent of Documents, Attn: New Orders, Box 371954, Pittsburgh, PA 15250-7954 (202) 783-3238. Copies of the FBOP Design Guidelines are available from the FBOP Project Manager
17. Executive Order 12699 “Seismic Safety of Federal and Federally Assisted or Regulated New Building construction”, and 41CFR128-1.8005.

1.3 SYSTEM DESCRIPTION

A. Primary Distribution for FCI and other campus facilities:

1. Two existing 15 kV class primary distribution systems currently serve the institution. One feeder should be considered the primary source for normal operating conditions. The second feeder will be used in the event of a primary feeder service interruption. Both feeders are being used simultaneously. All equipment required for the source switching is owned and operated by the local utility company.

2. Provide medium voltage generator paralleling switchgear for termination of the primary utility and generator feeders. The paralleling switchgear shall automatically transfer and synchronize the utility and emergency sources. See Section 26 10 00 - PARALLELING SWITCHGEAR for specific paralleling switchgear requirements. The paralleling switchgear will serve the institution's main distribution switchgear

3. Locate the main electrical service equipment for the institution in the new Central Utility Building.

   a. Provide a 15 kV class switchgear assembly for feeder circuit distribution to the institution. The North primary feeder will be extended to the new switchboard and paralleling gear. The East primary feeder is located on the other side of the campus from the new Central Utility plant and will be controlled through a new SCADA radio signaling system. (NOTE: all existing 15 kV distribution switches are currently controlled via a SCADA radio signaling system and the current system will be upgraded and refurbished as a part of this contract.)

   b. Refer to SINGLE LINE DIAGRAM: PRIMARY ELECTRICAL DISTRIBUTION - CENTRAL UTILITY PLANT for medium voltage switchgear arrangement. Existing distribution feeder circuits will include the following:

      1) Two dedicated primary selective looped feeders for the Secured Compound. Each primary feeder loop is sized to supply the full capacity of all secured compound buildings and remote facility electrical loads. See Riser Diagrams.

4. Configure the institution's primary distribution system to provide power to the new facility according to the following criteria:

   a. Central Utility Building: Provide a secondary unit substation with primary load interrupter switchgear, ventilated dry-type transformer, and low voltage distribution switchgear. Serve the unit substation from a dedicated primary selective radial feeder system. See Section 26 11 16 - SECONDARY UNIT SUBSTATIONS for dry-type transformer and technical information. Refer to SINGLE LINE DIAGRAM: PRIMARY ELECTRICAL DISTRIBUTION - CENTRAL UTILITY PLANT.

5. Provide alternate stand-by power generation equipment for the institution.

   a. The stand-by power source will be one (1) 15 kV class, diesel engine generator.
   b. The generator shall be required to serve 100% of the institution's operating electrical load, based on the peak demand of the facility provided by the Utility Company.

B. Data Collection Acquisition System:

1. As a stand-alone project, S&C IntelliTeam-SG will upgrade the existing 15kV loop feed, automatic switch controllers and the SCADA system with a new radio controlled SpeedNet radio system, and interface with the new main switchgear and generator in the Generator Building/Central Utility Plant to facilitate communications with the Maintenance Office and interface with the remote Eastern utility feeder. The S&C IntelliTeam-SG programming will automate intelligent transfer between the two utility feeds and the generator system and remote data from all of the systems through the SCADA HMI to the central Maintenance Office.

C. Equipment Upgrade:

1. The existing 5kV switchgear in the old Power Plant will be consolidated and the active units replaced.

1.4 SUBMITTALS

A. Provide "Operation and Maintenance" manuals. Upon substantial completion, 3 sets of "Operation and Maintenance" manuals are to be submitted. The manuals are to be in hardback, 3-ring, loose leaf binders covering details of operation and maintenance for all electrical apparatus requiring service. The manual format shall be as follows:

1. Title page with job name, Contractor's and Subcontractor's names, addresses, and telephone numbers.
2. Index sheet.
3. Manufacturer's operating and maintenance manuals, including wiring diagrams and parts lists for each piece of equipment and accessory requiring service or maintenance.
4. Warranty and guarantee information, including start and completion dates of the guarantee period, the name, address, and phone number of the nearest sales and service organization for each applicable item.
5. Complete description of functions and operations of each piece of equipment including description of how equipment operates. Instructions for cleaning, lubricating, routine inspections, tests, and maintenance procedures.
6. Copies of appropriate inspection certificates.
7. Copy of a final version of the "Over Current Protective Device Coordination" study required in Section 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.
8. Copy of the final version of ground integrity tests of the facility as required in Section 26 05 26 - GROUNDING AND BONDING ELECTRICAL SYSTEMS.

1.5 TRAINING

A. Upon substantial completion, the contractor shall arrange formal training sessions for Government's operating personnel.

1. The training sessions shall be digitally recorded (DVD Format) and one copy shall be provided at the conclusion of the training session.
2. The training sessions shall cover the following:

    a. General familiarization and operating procedures for the entire electrical installation.
    b. Routine maintenance procedures for all electrical equipment (using the Operation and Maintenance Manual as a reference book).
    c. Factory trained technicians shall give operating and maintenance instructions on: Medium and Low Voltage Switchgear, Transformers, Generators, Switchboards, SCADA upgrades and Radio System upgrades.

3. All training is to be performed by a factory-authorized source within 90 days of Final Acceptance.
4. All training dates shall be coordinated with FBOP Contracting Officer.

1.6 WARRANTEES

A. Unless otherwise noted, all standard and special warranties start at Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:

1. Use only prime quality new material.
2. Where multiple products are required furnish the entire group with the same manufacturer.

3. Immediately upon delivery of electrical equipment, inspect for any signs of shipping damage. Manufacturer’s literature shall be located and reviewed to insure compliance with requirements for storage.
4. When equipped with heater circuits, connect immediately to protect insulation and material from moisture damage.

PART 3 - EXECUTION

3.1 DEMONSTRATION

A. Upon substantial completion, all electrical systems shall have been started and verified to be in working order. A commissioning, startup and verification testing report for all major pieces of electrical equipment or electrical systems (generators, paralleling switchgear, exterior lighting, etc) shall be submitted which contains test sheets for each piece of equipment or system installed. Testing or commissioning procedures are found in individual MASTERSPEC or Technical Design Guidelines Sections. The test sheets will document the inspections, tests, adjustments and protective device settings made to each device as well as corrective action required.

B. Provide “Voltage Monitoring and Adjusting Testing.”

1. Demonstrate in the presence of the Owner that the electrical loads are properly balanced among the three phases and that the over current protection devices are operational.
2. Testing Procedures - Prior to Substantial Completion, perform “Voltage Monitoring and Adjusting Testing.” Perform a one day long test of the loading of the electrical system’s 3-phase voltage. Turn on as many of the electrical systems as feasible and record the voltage levels at the outgoing section of each primary step down transformer.
3. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch per hour.
4. Voltage unbalance between phases greater than 1 percent or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period is unacceptable. Measurements should take utility company incoming power into account. Variations and differences should be calculated using the incoming power as a base line value.
5. If the loads are unbalanced, perform the following corrective action as appropriate: adjust transformer taps, rebalance loads, prepare written request for voltage adjustment by the electric utility.

END OF SECTION

SECTION 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch lengths for each type of cable specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

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 IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

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

1. Aetna Insulated Wire, Inc.
2. General Cable; General Cable Corporation.
3. Kerite Co. (The).

B. Cable Type: Type MV 105.

C. Comply with UL 1072, AEIC CS8.

D. Conductor: Copper.

E. Conductor Stranding: Compact round, concentric lay, Class B.

F. Strand Filling: Conductor interstices are filled with impermeable compound.

G. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 15 kV.
2. Insulation Thickness: 133 percent insulation level.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

J. Cable Jacket: Sunlight-resistant PVC.

2.3 CONNECTORS

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

1. 3M.
2. Adalet.
3. G&W Electric Company.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

C. Copper-Conductor Connectors: Copper barrel crimped connectors.

2.4 SOLID TERMINATIONS

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

1. 3M.
2. Adalet.
3. G&W Electric Company.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include cold-shrink-rubber sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

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

1. 3M.
2. Adalet.
3. G&W Electric Company.

B. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Load-Break Cable Terminators: Elbow-type units with 200-A-load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Break Cable Terminators: Elbow-type unit with 200-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

F. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

G. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

H. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

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

1. 3M.
2. Adalet.
3. G&W Electric Company.

B. Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

2.7 MEDIUM-VOLTAGE TAPES

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

1. 3M.
2. Adalet.
3. G&W Electric Company.

B. Ethylene/propylene rubber-based, 30-mil splicing tape, rated for 130 deg C operation. Minimum 3/4 inch wide.

C. Silicone rubber-based, 12-mil self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches wide.

D. Insulating-putty, 125-mil elastic filler tape. Minimum 1-1/2 inches wide.

2.8 ARC-PROOFING MATERIALS

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

1. 3M.
2. Adalet.
3. G&W Electric Company.

B. Tape for First Course on Metal Objects: 10-mil-thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

C. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, and compatible with cable jacket.

D. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch wide.

2.9 FAULT INDICATORS

A. Indicators: Automatically reset fault indicator, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.10 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 or ICEA S-94-649 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

F. Install "buried-cable" warning tape 12 inches above cables.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

H. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

I. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

J. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

K. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

L. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1-inch-wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

M. Install fault indicators on each phase.

N. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

O. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

P. Identify cables according to Section 26 05 53 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
4. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

B. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Related Sections:

1. This work shall be coordinated with applicable parts of Division 02 and Divisions 27.

1.2 REFERENCES

A. National Fire Protection Association

1. NFPA 70 National Electric Code

B. InterNational Electrical Testing Association (NETA)

1. ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

1.3 SUBMITTALS

A. Inspection and test reports.

B. Calculations:

1. Provide calculations to verify that the resultant voltage drop for all feeders and branch circuits is not excessive, is in accordance with the National Electric Code and meets good design practice.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. All conductors shall be copper.

B. All conductors, regardless of size, feeding low voltage circuits (600 volts or less), HVAC equipment, motors and pumps shall be copper.

2.2 CONDUCTOR INSULATION TYPE

A. Cable and wire ratings shall be 90ºC (194ºF) and applied at the NEC 75ºC ampacity value for connections to interior over current protection devices.

B. Branch circuit wire insulation shall be THHN, THHW, or XHHW 600 volt, rated at 90ºC (194ºF).

2.3 FEEDERS AND BRANCH CIRCUITS NOT MORE THAN 600 VOLTS

A. Conductors for branch circuits shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combination of such loads.

B. Conductors shall be sized so that the maximum total voltage drop on both feeders and branch circuits to the farthest outlet shall not exceed 5 percent.

PART 3 - EXECUTION

3.1 APPLICATION

A. In no case shall the conductor be sized smaller than the following:

1. Power: 12 AWG.
2. Control: 14 AWG.
3. Analog/Digital signals and instrumentation: 16 AWG.
4. Current Transformer Secondary: 10 AWG.

3.2 INSTALLATION

A. Conductors up to #6 AWG shall be factory color coded. For conductors larger than #6 AWG, a 25 mm (1") wide band of colored tape on each conductor shall be used in accordance with NEC.

3.3 INSPECTION

A. All cables shall be inspected and tested by a qualified testing agency, independent from the installing contractor. Tests and inspections shall be per the cable manufacturers' guidelines and NETA standards.

END OF SECTION

SECTION 26 05 23
CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multimode optical-fiber cabling.
2. UTP cabling.
3. RS-485 cabling.
4. Low-voltage control cabling.
5. Identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

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.

2.2 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches.

B. Painting: Paint plywood on all sides and edges with flat eggshell latex paint.

2.4 OPTICAL-FIBER CABLE

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

1. 3M.
2. Belden CDT Networking Division/NORDX.
3. General Cable; General Cable Corporation.

B. Description: Multimode, 50/125-micrometer, 24-fiber, tight-buffer, optical-fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

    a. General Purpose, Conductive: Type OFCG or Type OFCP in listed communications raceway.

4. Conductive cable shall be aluminum-armored type.
5. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Aqua for 50/125-micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.5 OPTICAL-FIBER CABLE HARDWARE

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

1. ADC.
2. Belden CDT Networking Division/NORDX.
3. Berk-Tek Leviton; a Nexans/Leviton alliance.

B. Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA-568-C.3.
2. Quick-connect, simplex and duplex, Type SC or Type ST connectors. Insertion loss of not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.6 UTP CABLE

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

1. 3M.
2. Belden CDT Networking Division/NORDX.
3. General Cable; General Cable Corporation.

B. Description: 100-ohm, four-pair UTP, 25-pair UTP covered with a thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties of Category 5e cables.
2. Comply with ICEA S-102-700 for mechanical properties of Category 6 cables.
3. Comply with TIA-568-C.1 for performance specifications.
4. Comply with TIA-568-C.2, Category 5e or Category 6.
5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with NEMA WC 66, and NFPA 70 for the following types:

   a. Communications, General Purpose: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70.

2.7 UTP CABLE HARDWARE

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

1. ADC.
2. Belden CDT Networking Division/NORDX.
3. Hubbell Premise Wiring.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 5e or 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

E. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.

F. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

G. Workstation Outlets: Four-port-connector assemblies mounted in single or multigang faceplate.

H. Faceplates:
1. For use with snap-in jacks accommodating any combination of UTP, optical-fiber, and coaxial work area cords.

I. Legend:

1. Factory labeled by silk-screening or engraving.
2. Machine printed, in the field, using adhesive-tape label.

3. Snap-in, clear-label covers and machine-printed paper inserts.

2.8 TWIN-AXIAL DATA HIGHWAY CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, 12 pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.9 RS-485 CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.

2.10 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.11 SOURCE QUALITY CONTROL

A. Factory test UTP cables according to TIA-568-C.2.

B. Factory test optical-fiber cables according to TIA-568-C.3.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
2. Test each pair of UTP cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
2. Outlet boxes for optical-fiber cables shall be no smaller than 4 inches square by 2-1/8 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Secure conduits to backboard if entering the room from overhead.
3. Extend conduits 3 inches above finished floor.
4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
4. Cables may not be spliced.
5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lie on removable ceiling tiles.

11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. UTP Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Optical-Fiber Cable Installation:

1. Comply with TIA-568-C.3.
2. Terminate cable on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.

3.4 FIRESTOPPING

A. Comply with TIA-569-B, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping" Chapter.

3.5 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visually inspect UTP and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical-Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
        2) Attenuation test results for links shall be less than 2.0 dB.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

A. Insulated Conductors: Copper or tinned-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 B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
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 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 WG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

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

3.3 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 inches 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 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink 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 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 taps to equipment grounding terminals.

3.4 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.

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**,** tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 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 inches 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. 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. 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.

E. 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 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.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Requirements:

1. Section 26 05 48.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates: For hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

C. Welding certificates.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

1. Material: Pre-galvanized steel.
2. Channel Width: 1-5/8 inches.
3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M 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.

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, an Eaton business.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Ramset/Red Head; Illinois Tool Works, Inc.

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 A 325.
6. Toggle Bolts: All-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.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. 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.

E. 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 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

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

B. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

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

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. Standards: The design and construction of the facility shall comply with the following:

1. NFPA 70 - National Electric Code

1.2 DEFINITIONS

A. The following definitions shall apply for all Division 26 Sections.

1. Concealed: Above hard and suspended ceilings, and in walls, partitions, floors, pipe chases, pipe shafts, duct shaft, etc. In general, not visible from the occupied space.
2. Exposed: In finished and non-finished spaces, and visible from outside location. In general, visible from the occupied space.
3. Finished Spaces: All areas that require a finished ceiling.
4. Non-finished Spaces: All areas that have an exposed structure ceiling.
5. Secure Perimeter: The outer perimeter fence.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. The minimum conduit size shall be 21 mm (3/4 inch).
2. All conductors (power, communication, or signal) shall be installed in conduit.
3. Exposed conduits are required to be installed flat against the wall, or other vertical surface, secured with straps and non-removable security fasteners.
4. Rigid metal conduit is required, whether exposed or concealed, at all floor and security wall penetrations. Provide a protective coating at the transition point for rigid metallic conduit when conduit runs directly from concrete encasement to direct soil burial to prevent corrosive effects.
5. For electrical metallic tubing, compression fittings and metallic junction boxes are required.
6. Electrical non-metallic tubing is required to be tied at intervals not to exceed one (1) meter.
7. Metallic sheathed cable is permitted for whip connectors to light fixtures when the electrical connection is concealed above a gypsum or acoustical tile ceiling. Cable length is limited to a maximum length of 2 meters. Metallic sheathed cable shall be limited to MC type only. AC or BX cables shall not be acceptable.

PART 2 - PRODUCTS (Not used)

PART 3 - EXECUTION

3.1 INSTALLATION - Exterior within the secured compound, the following methods are required:

A. Exposed - Not permitted except for under roof structures where conduit is required to be rigid metal conduit. Example of such roof structures are loading docks, canopies, etc.

B. Underground - Concrete encased PVC rigid schedule 40. Refer to Section 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS for details.

C. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor driven equipment): liquid tight flexible metal conduit.

Table 1
Conduit Installation - Exterior Within the Secure Compound

Condition/Specific Area	RMC	IMC	EMT	ENT	FMC	LFMC	MC	BX	AC	PVC 40 *	PVC 40	PVC 80
Exposed	**X7**											
Exposed Under Roof Structure	**X**											
Exposed Behind Security Fencing	**X3**					**X4**						
Lighting	**X5**					**X6**						
Underground										**X**		
Connection to Vibrating Equipment						**X**						

Notes:
- ∗ Concrete Encased
- X Installation method permitted only if marked
- X1 Permitted with water tight Connections
- X2 Permitted only with cable length limited to 2 meters
- X3 Permitted with surface mounted on exterior wall for exterior equipment (condensers, split system units, etc)
- X4 Permitted from equipment disconnect to exterior disconnect
- X5 Permitted surface mounted on exterior wall for exterior lighting and security cameras at exterior stairs
- X6 Permitted from J box to light at exterior stairs

3.2 INSTALLATION - Exterior outside the secured compound, the following methods are required:

A. Exposed - Rigid metal conduit is required at heights between grade level and up to 3 meters. For heights above 3 meters, either rigid metal conduit or intermediate metal conduit is permitted.

B. Concealed - Either rigid metal conduit or intermediate metal conduit.

C. Underground - Concrete encased PVC rigid schedule 40. Refer to Section 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS for details.

D. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor driven equipment): liquid tight flexible metal conduit.

Table 2
Conduit Installation - Exterior Outside the Secure Compound

Condition/Specific Area	RMC	IMC	EMT	ENT	FMC	LFMC	MC	BX	AC	PVC 40 *	PVC 40	PVC 80
Exposed up to 3 Meters	X											
Exposed Above 3 Meters	X	X										
Concealed	X	X										
Underground										X		
Connection to Vibrating Equipment						X						

Notes:
- * Concrete Encased
- X Installation method permitted only if marked
- X1 Permitted with water tight Connections
- X2 Permitted only with cable length limited to 2 meters
- X3 Permitted with surface mounted on exterior wall for exterior equipment (condensers, split system units, etc)
- X4 Permitted from equipment disconnect to exterior disconnect
- X5 Permitted surface mounted on exterior wall for exterior lighting at exterior stairs
- X6 Permitted from J box to light or camera at exterior stairs

3.3 INSTALLATION - Interior within the secured compound, the following methods are required (See Table 3):

A. Secure Electronic Equipment Rooms, Mechanical Rooms, Electrical Rooms, Sprinkler Rooms, Elevator Machine Rooms, Compressor Rooms, etc - exposed conduit is permitted using: electrical metallic tubing, intermediate metal conduit, rigid metal conduit.

B. Secure Perimeter Corridor - Exposed conduit is not permitted from the finished floor to 3 meters above the finished floor. Exposed conduit above 3 meters is permitted using: intermediate metal conduit or rigid metal conduit.

C. General and Special Housing Units - Exposed conduit is not permitted with the exception of ceilings at a height of 3.6 meters or higher. For ceilings at a height of 3.6 meters or higher, exposed conduit is permitted using intermediate metal conduit or rigid metal conduit. Exposed conduit is not allowed on the wall and ceiling above the mezzanine level and within two (2) meters horizontal measurement from the hand rail location.

D. Indoor Active Recreation - Exposed conduit is not permitted with the exception of the ceiling. For ceilings, exposed conduit is permitted using intermediate metal conduit or rigid metal conduit.

E. Vocational Training Shops, Factories, Maintenance Shops, and Warehouses - Exposed conduit is permitted. Rigid metal conduit is required from the finished floor to 3 meters above the finished floor. Above 3 meters, exposed conduit is permitted using rigid metal conduit, intermediate metal conduit, or electrical metallic tubing.

F. Cell Chases in General and Special Housing - Exposed conduit is permitted using rigid metal conduit, intermediate metal conduit, or electrical metallic tubing.

G. Exposed - Unless specifically mentioned in sections A through F above, exposed conduit is not permitted.

H. Concealed above gypsum wallboard ceilings (offices, classrooms, exam rooms, storage, etc) - The use of either rigid metal conduit, intermediate metal conduit, or electrical metallic tubing is permitted.

I. Connection to Vibrating or Mechanical Equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor driven equipment) in wet or damp locations (kitchens, power-houses, pump rooms, etc.): liquid tight flexible metal conduit.

J. Damp or Wet Locations - Rigid metal conduit with watertight connectors.

K. Below On-grade Concrete Slab - PVC rigid schedule 40.

L. Unfilled CMU (masonry) - The use of either rigid metal conduit, intermediate metal conduit, or electrical metallic tubing is permitted.

M. Cast in Place Concrete (walls, slab on grade, topping slab, suspended slab, tunnel form) - The use of either rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or PVC rigid schedule 40 or 80 is permitted.

N. Pre-Cast Concrete (pre-cast panels, tilt-up, concrete modules, pre-cast elements) - The use of either rigid metal conduit, intermediate metal conduit, electrical metallic tubing, PVC rigid schedule 40 or 80, or electrical non-metallic tubing is permitted.

O. Embedded in Structural Footing for Lightning Protection Down Leads - Either electrical nonmetallic tubing or rigid nonmetallic conduit is required.

P. Embedded in grout filled CMU - PVC rigid schedule 40 or 80, electrical metallic tubing .

3.4 INSTALLATION - Interior outside the secured compound, the following methods are required (See Table 4):

A. Guard Tower Stairs (not including the Guard Tower CAB), Secure Electronic Equipment Rooms, Mechanical Rooms, Electrical Rooms, Sprinkler Rooms, Elevator Machine Rooms, Compressor Rooms, etc - exposed conduit is permitted using electrical metallic tubing, intermediate metal conduit, rigid metal conduit.

B. Dormitories - Exposed conduit is not permitted with the exception of ceilings at a height of 3.6 meters or higher. For ceilings at a height of 3.6 meters or higher, exposed conduit is permitted using intermediate metal conduit or rigid metal conduit.

C. Central Utility Plant, Vocational Training Shops, Garage/Landscape, Factories, Maintenance Shops, and Warehouses - Exposed conduit is permitted. Use rigid metal conduit from the finished floor to 3 meters above the finished floor. Above 3 meters, use rigid metal conduit, intermediate metal conduit, or electrical metallic tubing.

D. Exposed - Unless mentioned in A through C above, exposed conduit is not permitted.

E. Concealed above ceilings (either acoustic tile or gypsum board) - Use rigid metal conduit, intermediate metal conduit, or electrical metallic tubing.

F. Connection to Vibrating or Mechanical equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor driven equipment) in wet or damp locations (kitchens, power-houses, pump rooms, etc.): Liquid-tight flexible conduit.

G. Damp or Wet Locations - Rigid metal conduit with watertight connectors.

H. Below On-grade Concrete Slab - PVC rigid schedule 40.

I. CMU (masonry) - Use rigid metal conduit, intermediate metal conduit, or electrical metallic tubing.

J. Cast in Place Concrete (walls, slab on grade, topping slab, suspended slab, tunnel form) - The use of either rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or PVC rigid schedule 40 or 80 is permitted.

K. Pre-Cast Concrete (pre-cast panels, tilt-up, concrete modules, pre-cast elements) - The use of either rigid metal conduit, intermediate metal conduit, electrical metallic tubing, PVC rigid schedule 40 or 80, or electrical non-metallic tubing is permitted.

L. Embedded in Structural Footing for Lightning Protection Down Leads - Electrical nonmetallic tubing or rigid nonmetallic conduit.

M. Embedded in grout filled CMU - PVC rigid schedule 40 or 80, electrical metallic tubing.

Table 3
Conduit Installation - Interior Within the Secure Compound

Condition/Specific Area	**RMC**	**IMC**	**EMT**	**ENT**	**FMC**	**LFMC**	**MC**	**BX**	**AC**	**PVC 40 ***	**PVC 40**	**PVC 80**
Exposed - Security Electronics Room	**X**	**X**	**X**									
Exposed - Mechanical Room	**X**	**X**	**X**									
Exposed - Electrical Room	**X**	**X**	**X**									
Exposed - Sprinkler Room	**X**	**X**	**X**									
Exposed - Elevator Machine Room	**X**	**X**	**X**									
Exposed - Compressor Room	**X**	**X**	**X**									
Secure Perimeter Corridor - up to 3 meters												
Secure Perimeter Corridor - above 3 meters	**X**	**X**										
General Housing												
General Housing - Ceilings above 3.6 meters	**X**	**X**										
General Housing - Exposed in Cell Chase	**X**	**X**	**X**									

Table 3
Conduit Installation - Interior Within the Secure Compound

Condition/Specific Area	RMC	IMC	EMT	ENT	FMC	LFMC	MC	BX	AC	PVC 40*	PVC 40	PVC 80
Special Housing												
Special Housing - Ceilings above 3.6 meters	X	X										
Special Housing - Exposed in Cell Chase	X	X	X									
Indoor Recreation - Ceilings	X	X										
Vocational Training - up to 3 meters	X											
Vocational Training - above 3 meters	X	X	X									
Factories - up to 3 meters	X											
Factories - above 3 meters	X	X	X									
Maintenance Shops - up to 3 meters	X											
Maintenance Shops - above 3 meters	X	X	X									
Warehouses - up to 3 meters	X											
Warehouses - above 3 meters	X	X	X									
Other Exposed Areas												
Concealed Above Gypsum Board Ceilings	X	X	X									
Concealed Above Gypsum Board Ceiling - Light Fixture Connection							X2					
Connection to Vibrating Equipment						X						
Damp/Wet Locations	X1											
Below On-Grade Concrete Slab											X	
Unfilled CMU Masonry	X	X	X									
Cast-in-Place Concrete (Walls, Slabs, Tunnel Forms)	X	X	X								X	X
Pre-Cast Concrete (Panels, Tilt-Up, Modules, Element)	X	X	X	X							X	X
Embedded in Structural Footing (Lightning Protection)				X							X	X
Embedded in Grout Filled CMU											X	X
Embedded in Structural Footing				X							X	X

Table 3
Conduit Installation - Interior Within the Secure Compound

Condition/Specific Area	RMC	IMC	EMT	ENT	FMC	LFMC	MC	BX	AC	PVC 40 *	PVC 40	PVC 80
(Lightning Protection)												
Embedded in Grout Filled CMU											X	X

Notes:
- * Concrete Encase Ductbank
- X Installation method permitted only if marked
- X1 Permitted with water tight Connections
- X2 Permitted only with cable length limited to 2 meters

Table 4
Conduit Installation - Interior Outside the Secure Compound

Condition/Specific Area	RMC	IMC	EMT	ENT	FMC	LFMC	MC	BX	AC	PVC 40 *	PVC 40	PVC 80
Guard Tower Stairs	X	X	X									
Exposed - Security Electronics Room	X	X	X									
Exposed - Mechanical Room	X	X	X									
Exposed - Electrical Room	X	X	X									
Exposed - Sprinkler Room	X	X	X									
Exposed - Elevator Machine Room	X	X	X									
Exposed - Compressor Room	X	X	X									
Central Utility Plant - up to 3 meters	X											
Central Utility Plant - above 3 meters	X	X	X									
Vocational Training - up to 3 meters	X											

Table 4
Conduit Installation - Interior Outside the Secure Compound

Condition/Specific Area	**RMC**	**IMC**	**EMT**	**ENT**	**FMC**	**LFMC**	**MC**	**BX**	**AC**	**PVC 40***	**PVC 40**	**PVC 80**
Vocational Training - above 3 meters	**X**	**X**	**X**									
Garage/Landscape - up to 3 meters	**X**											
Garage/Landscape - above 3 meters	**X**	**X**	**X**									
Factories - up to 3 meters	**X**											
Factories - above 3 meters	**X**	**X**	**X**									
Maintenance Shops - up to 3 meters	**X**											
Maintenance Shops - above 3 meters	**X**	**X**	**X**									
Warehouses - up to 3 meters	**X**											
Warehouses - above 3 meters	**X**	**X**	**X**									
Other Exposed Areas												
Concealed Above Gypsum Board Ceilings	**X**	**X**	**X**									
Concealed Above Gypsum Board Ceiling - Light Fixture Connection							**X2**					
Connection to Vibrating Equipment						**X**						
Damp/Wet Locations	**X1**											
Below On-Grade Concrete Slab											**X**	
Unfilled CMU Masonry	**X**	**X**	**X**									
Cast-in-Place Concrete (Walls, Slabs, Tunnel Forms)	**X**	**X**	**X**								**X**	**X**

Table 4
Conduit Installation - Interior Outside the Secure Compound

Condition/Specific Area	RMC	IMC	EMT	ENT	FMC	LFMC	MC	BX	AC	PVC 40 *	PVC 40	PVC 80
Pre-Cast Concrete (Panels, Tilt-Up, Modules, Element)	X	X	X	X							X	X
Embedded in Structural Footing (Lightning Protection)				X							X	X
Embedded in Grout Filled CMU											X	X

Notes:
* Concrete Encased Ductbank
X Installation method permitted only if marked
X1 Permitted with water tight Connections
X2 Permitted only with cable length limited to 2 meters

END OF SECTION

SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The requirements in this Technical Design Guidelines Section shall be coordinated with Section 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS as noted below.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM A1011 / A1011M - 10 Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

B. Federal Standards (FS)

1. FED-STD TT-V-51 (Rev F) Varnish: Asphalt

C. InterNational Electrical Testing Association (NETA)

1. ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

1.3 SYSTEM DESCRIPTION

A. Ductbanks:

1. All power and communication distribution external to a building shall be in an underground concrete encased electrical distribution system, with the exceptions identified in paragraph 1.3.A.2 below. Examples of distribution system components which require concrete encased underground ductbanks are included but not limited to:

a. Any required extensions of the utility company's incoming electrical service from utility company's point of connection into the Central Utility Plant.
b. Primary power loop distribution from the Central Utility Plant (secure compound, Administration Building, support buildings; camp housing, camp core, warehouses, garage/landscape, etc) to selector switches located throughout the institution.
c. Power distribution from selector switches to pad mounted transformers.
d. Power distribution from pad mounted transformers into building electrical rooms.
e. Power distribution to exterior lighting systems (high mast, roadway, parking lot, etc).
f. Any Medium and low voltage power distribution.
g. All communication systems.

2. Concrete encasement requirement does not apply to the conduit installed underground for the following Division 27 and 28 Equipment:

a. Perimeter Detection System, when protected by concrete pavements.
b. Intercoms associated with the Rear Vehicle Sallyport, when protected by concrete pavements.

c. Cameras associated with the Rear Vehicle Sallyport, when protected by concrete pavements.
d. Vehicle sallyport sliding gate and pedestrian gate control circuits when protected by concrete pavements.

3. For single or multiple conduit assemblies encase in concrete, provide details and sections of concrete encased underground ductbanks indicating size of ducts, thickness of encasement, thickness of concrete between various ducts and burial depth required.

B. Manholes:

1. Ductbank turn ups into pad mounted equipment (such as transformers or selector switches) shall not be considered a manhole. When considering manhole placement based on separation distances listed above in paragraph #2, ductbank turn ups into equipment shall not relieve the requirement for a manhole.

PART 2 - PRODUCTS

2.1 DUCTS

A. Conduit and Fittings: All conduit and fittings in the ductbanks shall be PVC rigid Schedule 40 and shall be encased in concrete. Aluminum conduit shall not be permitted.

B. Ductbank encasement material shall be 21 MPa (3000 psi) concrete under roads and buildings. Extend concrete ductbank a minimum of 2 m beyond roadway shoulder and 2 m from building foundation walls. Remaining ductbank encasement material may be substituted with a Controlled Low-Strength Materials (CLSM) having a 6.9 MPa (1000 psi) minimum compressive strength in lieu of concrete. The CLSM shall be in accordance with ACI 229R-99; except that the Contractor is not permitted to use nonstandard materials. Contractor shall provide in the project design specifications the proportioning of ingredients of the mix and shall indicate the performance features that the mix is to obtain. Comply with requirements in Section 03 31 00 “Structural Concrete.”

2.2 MANHOLES

A. Concrete shall be 4000 psi at 28 days.

B. Manholes:

1. Provide cast covers with cast-in legend “ELECTRIC-LV” for duct systems with power wires and cables for systems operating at 600 volt or less.
2. Provide cast covers with cast-in legend “ELECTRIC-HV” for duct systems with medium voltage cable.
3. Provide cast covers with cast-in legend “SIGNAL” for communications, data, and telephone duct systems.

2.3 ACCESSORIES

A. For each manhole, provide a UL-listed fiberglass or steel ladder specifically designed for manhole use.

PART 3 - EXECUTION

3.1 DUCTS

A. Underground minimum duct sizes are as follows: 129 mm (5") underground ductbank for primary electric power distribution, 103 mm (4") underground ductbank for secondary electric power distribution (typically from transformer into the building's electric room), 103 mm (4") duct for underground communication ductbank (with the exception noted below).

1. The 103 mm minimum conduit requirement does not apply to the perimeter security system. Conduit sizes for this system are to be as specified in details in the Division 17 Model Documents.

B. The minimum separation between ducts for power cables shall be in accordance with NEC Figure 310-60.

C. A minimum of two (2) spare ducts or 25% spare ducts, whichever is greater, for all underground power distribution service shall be included for future expansion.

D. A minimum of 50% spare ducts for all underground communication distribution service shall be included for future expansion. This spare capacity requirement does not apply to the conduit installed for the Perimeter Security System.

E. Install concrete encased underground ductbanks at a minimum depth of 915 mm (36") below final grade.

F. Where it is necessary to run communication ducts and/or low voltage ducts along with electric power distribution ducts, separate the communication and power distribution ducts by 305 mm (12") of concrete and provide an isolated system for each in separate manhole compartments.

G. Primary Power Distribution Loop - No utility lines of any kind shall be routed under buildings, parking lots, paved terraces, sidewalks, and other paved areas, except as listed in part 1.3.A.2 of this section. When electric and communication lines must pass under paved roads, parking lots, or buildings, the concrete encased ducts shall be reinforced. See Figure 1, Detail 26 05 43-D1.

3.2 MANHOLES/HANDHOLES

A. Manhole separation shall not exceed 180 m (600') on straight pulls and 90 m (300') on curved duct runs.

B. For the Perimeter Detection System, concrete encased manholes or handholes are not required. Provide installation of this system as specified in the Division 27 and 28 Model Documents.

END OF SECTION

SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

   a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

   a. Advance Products & Systems, Inc.

b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.

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

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

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

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

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

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
    b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

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 is to be installed or unless 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 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 05 48.16
SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic- and Wind-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the 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. 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).

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 90 MPH.
2. Building Classification Category: II.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: B.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
    a. Component Importance Factor: 1.0
    b. Component Response Modification Factor: 1.5.
    c. Component Amplification Factor: 1.0.

2.2 RESTRAINT CHANNEL BRACINGS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

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

1. Kinetics Noise Control, Inc.
2. Loos & Co., Inc.

B. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

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

1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

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 MECHANICAL ANCHOR BOLTS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.

B. Mechanical Anchor Bolts: 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 required for anchor and as tested according to ASTM E 488.

2.6 ADHESIVE ANCHOR BOLTS

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

1. Hilti, Inc.

2. Kinetics Noise Control, Inc.

B. Adhesive Anchor Bolts: 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 E 488.

PART 3 - EXECUTION

3.1 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 hanger-rod stiffeners 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 present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. 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.

B. Install cables so they do not bend across edges of adjacent equipment or building structure.

C. 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.

D. 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.

E. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the 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. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. 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.

3.3 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 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.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least 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.

B. Seismic controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

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

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

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

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. 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."
3. Arc flash warning: Danger – Arc Flash Hazard. Appropriate PPE required… Etc.

2.3 LABELS

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: 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. LEM Products Inc.
d. Panduit Corp.

B. Self-Adhesive Labels:

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

a. Brady Corporation.
b. LEM Products Inc.
c. Panduit Corp.

2. Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
3. Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

a. Nominal Size: 3.5-by-5-inch.

2.4 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.

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.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.

C. 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 the following:

   a. Carlton Industries, LP.

D. Underground-Line Warning Tape

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

   a. Brady Corporation.
   b. Ideal Industries, Inc.
   c. LEM Products Inc.
   d. Marking Services, Inc.
   e. Reef Industries, Inc.

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".
   c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

2.5 Signs

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

   a. For signs up to 20 sq. inches, minimum 1/16-inch-.
   b. For signs larger than 20 sq. inches, 1/8 inch thick.
   c. Engraved legend with white letters on a dark grey background.
   d. Punched or drilled for mechanical fasteners.

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

   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. emedco.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Apply identification devices to surfaces that require finish after completing finish work.

C. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

D. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

E. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

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

F. 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.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways, 600 V or Less, for Service and, Feeder, Identify with self-adhesive vinyl label self-adhesive vinyl tape applied in bands. Install labels at 30-foot maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use industry standard colors for ungrounded service feeder and branch-circuit conductors.

   a. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Conductors to Be Extended in the Future: Attach write-on tags marker tape to conductors and list source.

E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Install underground-line warning tape for cables in raceways.

G. Workspace Indication: Install floor marking tape to 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.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. 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. Double ended switchboards.

I. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 26 05 74 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.

1. Labeling Instructions:

   a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 3/8-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
e. Indicate location, source of power and circuit number.

END OF SECTION

SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.
2. Study shall verify there are no coordination problems prior to ordering equipment.

1.2 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.3 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals **may** be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

   a. Submit study report for action prior to receiving final approval of the 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 the selection of devices and associated characteristics is satisfactory.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Software Developer and Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. Include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.
2) Protective device coordination study.
3) Time-current coordination curves.

b. Power system data.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

a. Phase and Ground Relays:

1) Device tag.
2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

G. 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 the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the 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. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

    1. 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.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall 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 according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Paralleling Switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Standby generators and automatic transfer switches.
7. Branch circuit panelboards.

M. 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. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the 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.

3.4 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and 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.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.

5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. 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.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing 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 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. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the 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 shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

SECTION 26 05 74
OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals may be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the 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 the selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Software Developer.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: Provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.5 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

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

a. EDSA Micro Corporation.
b. Operation Technology, Inc.
c. Power Analytics, Corporation.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Arc-Flash Study Output:

1. 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 a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. 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. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. 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.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

D. Include low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

E. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

F. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.

G. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

H. 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.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Electrical Survey Data: Gather and tabulate the following input data to support study.

1. Product Data for overcurrent protective devices specified in other Sections and 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.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. 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.
5. Motor horsepower and NEMA MG 1 code letter designation.
6. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy and vacancy sensors
6. Digital timer light switches.
7. High-bay occupancy and vacancy sensors.
8. Outdoor motion sensors.
9. Lighting contactors.

B. Related Requirements:

1. Section 26 27 26 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 TIME SWITCHES

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

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Invensys Controls.
4. Leviton Manufacturing Co., Inc.
5. NSi Industries LLC.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST or DPST DPDT.
3. Contact Rating: 30-A inductive or resistive.
4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
6. Astronomic Time: All channels.
7. Automatic daylight savings time changeover.
8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. NSi Industries LLC.

B. Description: Solid state, with dry contacts rated for, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

6. Failure Mode: Luminaire stays ON.

C. Description: Solid state; one set of NO dry contacts rated to operate connected load, complying with UL 773, and compatible with power pack.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Mounting: 1/2-inch threaded male conduit.
5. Failure Mode: Luminaire stays ON.
6. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

   a. LED status lights to indicate load status.
   b. Plenum rated.

7. Power Pack: Digital controller capable of accepting three RJ45 inputs with one or two outputs rated for 20-A incandescent or LED load at 120- and 277-V ac. Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.

   a. With integral current monitoring
   b. Compatible with digital addressable lighting interface.
   c. Plenum rated.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. Square D.

B. General Requirements for Sensors:

1. Wall or Ceiling-mounted, solid-state indoor occupancy sensors.
2. Dual technology.
3. Integrated power pack.
4. Hardwired connection to switch; control system.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

   a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   b. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected load, complying with UL 773A.
8. Power: Line voltage.
9. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

10. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
11. Bypass Switch: Override the "on" function in case of sensor failure.
12. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet when mounted 48 inches above finished floor.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. Square D.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, using hardwired connection using wireless connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Dual voltage - 120 and 277 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White.
11. Faceplate: Color matched to switch.

2.5 OUTDOOR MOTION SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. General Requirements for Sensors: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Dual-technology (PIR and infrared) type, weatherproof. Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.. Comply with UL 773A.
3. Switch Rating:

   a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED.
   b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP, dual circuit SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Dual voltage, 120- and 277-V type.
6. Detector Coverage:

   a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft..
   b. Long Range: 180-degree field of view and 110-foot detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
10. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.

11. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as "raintight" according to UL 773A.

2.6 LIGHTING CONTACTORS

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

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP; a business of Emerson Network Power.
3. Eaton Corporation.
4. General Electric Company.

B. Description: Electrically operated and mechanically electrically held, combination-type lighting contactors with fusible switch nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

D. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

E. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 26 10 00
PARALLELING SWITCHGEAR

PART 1 - GENERAL

1.1 COORDINATION

A. Coordinate with the following Sections:

1. 26 11 16 – SECONDARY UNIT SUBSTATIONS.

B. The building's overcurrent protection devices shall be properly coordinated so that the closest breaker or tripping device upstream from the fault will be the one to trip. See Section 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.

1.2 REFERENCES

A. Standards - The design and construction of the facility shall comply with the following:

1. American Society for Testing and Materials

ASTM A 345	Flat-Rolled Electrical Steels for Magnetic Applications
ASTM A 366	Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM B 48	Soft Rectangular and Square Bare Copper Wire for Electrical Conductors
ASTM D 117	Electrical Insulating Oils of Petroleum Origin
ASTM D 3487	Mineral Insulating Oil Used in Electrical Apparatus
ASTM D 635	Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM D 877	Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

2. Federal Standards

FED-STD 595	Colors

3. Institute of Electrical and Electronic Engineers

IEEE C2	National Electrical Safety Code
IEEE C37.20.2	Metal-Clad and Station-Type Cubicle Switchgear
IEEE Std 1	General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation
IEEE Std 4	Standard Techniques for High Voltage Testing

4. National Electrical Manufacturers Association

NEMA 210	Secondary Unit Substations

5. InterNational Electrical Testing Association (NETA)

ATS	Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

1.3 SUBMITTALS

A. Calculations

1. Provide calculations to validate that short circuit interrupting ratings of the over current protective devices are adequate and properly coordinated, relative to the maximum available fault current. See FBOP requirements in Section 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY. Calculations to indicate that not only are downstream over-current protection devices properly coordinated, but that the secondary unit substation is properly coordinated with paralleling switchgear and medium voltage switchgear.
2. Provide calculations to verify transient voltage surge suppression ratings.

B. Shop Drawings:

1. Single line diagrams showing major components and features of the electrical distribution system.
2. A copy of the single line diagram of the building's electrical distribution system shall be framed under Plexiglas and mounted on the wall adjacent to the substation.
3. Diagram of the substation showing utility company's primary feeders, transformer characteristics, switchgear/switchboard sections, and all instruments and control wiring.

1.4 SYSTEM DESCRIPTION

A. The institution paralleling switchgear shall be located inside the Central Utility Plant. Provide paralleling switchgear for termination of the utility and standby power generation sources.

B. Fuses: Provide six of each type and rating used. Include spares for potential transformers, control power circuits, and fusible devices. Fuses shall match type installed and be packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PARALLELING SWITCHGEAR

A. Basis-of-Design Product: Subject to compliance with requirements, provide a Paralleling Switchgear by Cummins Power Generation with Square D Breakers as shown on the drawings, or comparable product by one of the following below. Cost associated with the redesign from a non-approved manufacturer shall be the financial responsibility of the installing contractor.
1. Cummins
2. Russelectric
3. ASCO
4. Or Engineered Approved Equal, as long as the product is compliant with the Buy American Act. Written approval must be given 2 weeks prior to bid with a line by line compliance statement demonstrating compliance, deviations, and exceptions..

B. The generator control and distribution switchgear shall consist of 15 kV class, medium voltage metal-clad switchgear, with horizontal draw out vacuum circuit breakers, and separate engine control, utility, and load cubicles. The system shall operate as an integrated system to control incoming utility power and onsite standby diesel engine generator power with output primary feeder circuits that serve the institution's main double-ended distribution switchgear.

C. Circuit Breakers:

1. Provide 15 KV, 60 Hz circuit breaker with a continuous current rating of 1,200 amperes and 40kA short circuit current rating at full voltage. All circuit breakers of equal rating shall be interchangeable. Circuit breakers shall be horizontal draw out type with self-aligning line-side and load-side disconnecting devices. Primary disconnecting contacts shall be silver-plated copper.
2. Each circuit breaker shall contain three (3) vacuum interrupters separately mounted in a self-contained, self-aligning housing which can be removed as a complete unit.

   a. Current transformers shall be furnished and installed on each phase of every vacuum circuit breaker with CT ratios as shown on the project drawings.

3. The breakers and protective relays shall be powered by 125VDC.

D. Accessories

1. The switchgear manufacturer shall furnish accessories for test, inspection, maintenance, and operation, including:

   a. One – Maintenance tool for manually charging the breaker closing spring and manually opening the shutter
   b. One – Levering crank for moving the breaker between test and connected positions
   c. One – Test jumper for electrically operating the breaker while out of its compartment
   d. One – Breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails, when applicable
   e. One – Set of rail extensions and rail clamps, when applicable

E. Configure switchgear for fully automatic or manual operation at the discretion of the operator. Each switchgear section shall be complete and include the necessary AC instrumentation, relaying, voltage regulator equipment, generator control equipment, engine governor controls, indicator lights, selector switches, etc., and accessories as described hereinafter.

F. Utility Protective Relays: At a minimum, incoming utility power shall have overcurrent protection with the following relay functions. The utility grade protective relay shall be SEL351S or approved equal.

1. Undervoltage Relay (27).
2. Directional Power Relay (32).
3. Negative Sequence Current Relay (46N).
4. Phase Sequence or Phase Balance Voltage Relay (47).
5. Instantaneous Overcurrent Relay (50).
6. Time Overcurrent Relay (51).
7. Overvoltage Relay (59).
8. Frequency Relay (81).
9. Synchro Check Relay (25).

G. Generator Protective Relays: At a minimum, incoming utility power shall have overcurrent protection with the following relay functions. The utility grade protective relay shall be SEL700G or approved equal.

1. Undervoltage Relay (27).
2. Directional Power Relay (32).
3. Negative Sequence Current Relay (46N).
4. Phase Sequence or Phase Balance Voltage Relay (47).
5. Instantaneous Overcurrent Relay (50).
6. Time Overcurrent Relay (51).
7. Overvoltage Relay (59).
8. Frequency Relay (81).

9. Synchro Check Relay (25).
10. Differential Phase Fault (87G)
11. Loss of Field (40)

H. Feeder and Tie Protective Relays: At a minimum, incoming utility power shall have overcurrent protection with the following relay functions. The utility grade protective relay shall be SEL551 or approved equal.

1. Instantaneous Overcurrent Relay (50).
2. Time Overcurrent Relay (51).

I. All protective relays are to be equipped with a maintenance mode switch that will reduce the trip settings down to their lowest settings. Maintenance switches shall cause a blue light to flash to indicate the switch has been initiated.

J. Design, test and assemble the generator control and distribution switchgear in strict accordance with all applicable standards of ANSI, UL, IEEE and NEMA.

K. To provide for single source responsibility each individual section of the switchgear lineup including engine generator control sections, master synchronizing control sections, and distribution breaker sections with all internal components mounted shall be UL listed and labeled under the switchgear manufacturer's name.

L. Provide the paralleling/synchronizing switchgear with the following instruments and sensors. (All door mounted indicator lights shall be LED type).

1. Ammeters and Voltmeters, or digital equivalent: Analog indicating instruments with 115-mm square recessed case and 250-degree scale, white dial with black figures, 5 ampere, 60-Hertz movement, one percent accuracy.
2. Ammeter and Voltmeter Transfer Switch, or digital equivalent: Rotary multistage snap-action type with 600 volt AC-DC silver plated contacts, engraved escutcheon plate, pistol-grip, round, knurled handle, with four positions including OFF.
3. Instrument Control Switches, or digital equivalent: Heavy-Duty, rotary switchgear type rated 30 ampere at 600VAC.
4. Current Transformers: 5-ampere secondary wound type, with single secondary winding and primary/secondary ratio as required.
5. Potential Transformers (Three, one for each phase, on the utility side of the main breaker and three, one for each phase, on the load side of the main horizontal bus): 120-volt single-phase secondary with primary and secondary fuse protection.
6. Engine Generator Selector Switch, or digital equivalent: Provide a four-position engine selector switch labeled, "Lockout/Reset-Off-Auto-Run," on each engine generator control panel cubicle door.
7. "Load Test-Normal" Switch, or digital equivalent: Provide a two-position, key-operated test switch labeled "Load Test-Normal" in the master control section to permit operation and testing as follows:

    a. When the switch is placed in the "Test" position, automatic start of the generators shall occur and all automatic synchronizing and transfer functions shall operate.
    b. Returning the switch to the "Normal" position shall open the generator circuit breakers and initiate the cool down cycle of the engine generators, and restore all equipment to normal operation.

8. Master "Manual-Auto" Control Switch (Two-Position), or digital equivalent: Whenever the master "Manual-Auto" control switch is placed in the "Manual" position, the engine generator power circuit breakers and synchronizing shall be operated manually. Provide a swing panel in the

master control section with Synchroscope, synchronizing lights, frequency meter and bus voltmeter for manual synchronizing through the engine generator power circuit breaker control switches, the Synchroscope switches, and the frequency meter switches on the engine generator control section door if not provided at the generator controller and touchscreen.

9. Fail to Synchronize Time Delay Relays, or digital equivalent: Provide a fail to synchronize time delay relay for each generator to terminate the operation of the synchronizer and sound a warning horn, in the event the generator is unable to be synchronized within an adjustable period of time, approximately 0-3 minutes.
10. Fail Light, Lockout, and Alarm System: Provide each engine generator power circuit breaker and control section with separate alarm relays and alarm lights, to shut down the engine generator, disconnect it from the main bus, and illuminate a light to indicate the nature of the failure.
11. Selector Switch Coordination: Coordinate the functions and circuitry of the various selector switches, to insure that the various settings available do not cause malfunction in the intended system operation.
12. Automatic Synchronizer: Provide automatic synchronizers, one for each engine generator, with the following features and capabilities:

    a. A bipolar DC output signal suitable for driving a governor/amplifier system.
    b. A sync contact closure to operate the selected power circuit breaker when the incoming voltage has the same amplitude, frequency and phase as the main switchboard bus.
    c. Synchronizer controls consisting of phase offset, gain, and stability control. To insure optimum compatibility with the governor control, the synchronizer shall be by the same manufacturer of the governor control system.

M. Engine Generator Controller:

1. A programmable logic controller (PLC) or microprocessor will control the engine starting. Provide a separate PLC/mircroprocessor for each engine generator. Programming shall be the responsibility of the generator control switchgear manufacturer.
2. Provide a programmable timer access module for each engine generator to allow for the following field adjustable time settings:

    a. Fail to synchronize (30 to 240 seconds).
    b. Cool down time (5 to 40 minutes).
    c. Crank attempts (1 to 8 attempts).
    d. Crank duration (5 to 40 seconds).
    e. Rest duration (5 to 40 seconds).
    f. Spare #1.
    g. Spare #2.

3. Provide an “enter” push-button on the programmable timer access module to allow revised settings to be downloaded into the PLC/microprocessor. Show the following status with an indicating LED on the module:

    a. Off - Setting accepted.
    b. Flashing - Settings being downloaded.
    c. Solid On - Invalid switch settings.

4. Provide each PLC/microprocessor with a separate power supply for input power, to prevent against over voltage conditions and to maintain sufficient control power to the PLC during engine cranking.

N. System Programmable Controller:

1. Provide one PLC for system control. PLC programming for system operation is the responsibility of the switchgear manufacturer. The PLC monitors loss of utility via inputs from the under voltage relay in the utility transfer control cubicle. Provide a password protected, Operator Interface Touch-Screen, programmable controller on the master control cubicle door. Hand-held PLCs and/or laptop computers are not acceptable.

O. Paralleling Switchgear Battery and Battery Charger:

1. Provide two (2) sets of redundant station batteries, battery chargers, controls and indicators housed in self-contained freestanding consoles cooled by convection. Provide a best battery selector that automatically chooses the battery with the highest charge to power the switchgear.
2. Operation shall be completely automatic with the chargers maintaining the batteries fully charged under all normal service conditions.
3. Include front-panel-mounted DC voltmeter, DC ammeter, float charged indicator, and high-rate charge indicator in the consoles. The consoles shall also have a potentiometer for adjusting float charge voltage and a potentiometer for adjusting the high-rate voltage. Equip these controls with AC and DC fuses and an AC and DC failure alarm relay. Equip the console with an automatic 24-hour timer installed within the cabinets. Following an AC power failure longer than 8-12 seconds, the timer will automatically switch the chargers to the high-rate mode. After the preset interval, the timer returns the batteries to float charge.
4. Provide nickel cadmium, pocket plate, alkaline type storage batteries of domestic manufacture in plastic containers.
5. The batteries shall be designed for nominal 125-volt DC switchgear service and shall be capable of delivering 110 ampere-hour capacity (or higher, if recommended by the paralleling switchgear manufacturer), at the 8-hour rate.
6. Provide constant-potential, two-rate type battery chargers with a regulated output voltage stability of +/-1 percent from zero to full nominal current rating over an input voltage variation of 10 percent. Input shall be 120 volts, 60 Hertz, single phase, AC with a nominal output of 10 amperes at 125 volts DC.
7. Provide DC-DC converter for converting 24V DC generator batteries to 125V DC. Best battery selector to be sized to handle three input sources.

P. Engine Cranking System: The engine cranking system shall permit at least eight (8) cranking attempts of 5 to 40 seconds duration, with rest periods of 10 seconds. Provide means to allow for a continuous cranking cycle, if required.

Q. Ground Fault Protection:

1. Provide each of the primary circuits connected to the utility and generator medium voltage switchgear with a zero sequence type ground fault relay.
2. Single Phase Protection: Provide open phase detectors on the incoming utility service. Switchgear shall have integral test switch for verification of detector control circuitry operation by simulating a single-phase condition that disconnects control power to the detector relays. Simulation of single-phase condition shall be included as part of the switchgear commissioning tests.

2.2 PARALLELING SWITCHGEAR OPERATIONAL OVERVIEW

A. Coordinate and integrate all system operation and control functions such that during automatic and/or manual operation, no unsafe condition occurs, no malfunction of intended operation occurs, and the highest possible reliability of operation is maintained.

B. Normal Mode

1. The utility main breaker are closed.
2. The generator main breakers are open.

3. The automation is standing by to act in response to a utility failure.

C. Utility Failure

1. Utility protective relaying senses utility voltage or frequency out of tolerance.
2. The utility main breaker is opened.
3. A run request is sent to the generator plant.
4. The first generator up to voltage and frequency is closed to the generator bus.
5. The remaining generators are synchronized and paralleled to the bus as they come up to voltage and frequency.
6. The system is now in Emergency Mode.

D. Restoration of Utility Service

1. Utility protective relaying senses utility voltage and frequency within tolerance.
2. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power source is stable, the generator plant is passively synchronized and paralleled to the utility source by closing the north utility main breaker.
3. The generator plant is soft ramp unloaded until the utility source is nominally serving the entire system load.
4. The generator breakers are opened.
5. The generators are allowed to run for their programmed cool down period.
6. The system is now back in Automatic/Standby Mode.

E. Closed Transition Entry to Emergency Mode

1. The operator places the Master Mode Selector Switch into the Transfer to Emergency position.
2. A run request is sent to the generator plant.
3. The first generator up to voltage and frequency is closed to the generator bus.
4. The remaining generators are synchronized and paralleled to the bus as they come up to voltage and frequency.
5. The generators are allowed to run for a five-minute warm-up time (which can be abbreviated by the operator).
6. After completion of the warm-up time, the generator plant is passively synchronized and paralleled to the utility source by closing the emergency tie breaker.
7. The generator plant is soft ramp loaded until it is serving nominally the entire load on the bus and the utility main breaker is opened.
8. The system is now in Emergency Mode.

F. Closed Transition Exit from Emergency Mode

1. The operator removes the Master Mode Selector Switch from Transfer to Emergency position and returns it to the Auto position.
2. Following an adjustable time delay (which can be abbreviated by the operator), the generator plant is passively synchronized and paralleled to the utility source by closing the utility main breaker.
3. The generator plant is soft ramp unloaded until the utility source is nominally serving the entire system load.
4. The generator breakers are opened.
5. The generators are allowed to run for their programmed cool down period.
6. The system is now back in Automatic/Standby Mode.

G. Load Prioritization:

1. Establish a final load list that prioritizes all circuit breakers involved with the backup power and cooling system. Document in detail the sequence of events used for energizing the generators and connecting the backup loads. Divide the list into incremental steps that list the following:

   a. Sequence of event number.
   b. Sequence of event description.
   c. Time in seconds for events.
   d. Accumulative time in seconds.

2. Provide a sequence of prioritizing block step loads. Coordinate with the voltage transient analysis and take into account the magnetizing inrush currents of the transformers served by the primary distribution system.
3. Close the main distribution feeder circuit breaker. The single generator is sized to handle the peak demand load of the facility. To insure that the inrush stays within 10%, the radio controlled sectionalizing switches will disconnect the UNICOR facility and the Central Chiller Plant and bring those loads on after the generator stabilizes.

   a. Priority #1: Radial Feeders for the Central Plant (excluding HVAC chillers and associated pumps) and waste water building.
   b. Priority #1: Radial Feeders for the Outside Administration Building (from which is fed the Rear Vehicle Sallyport and Guard Towers).
   c. Priority #1: Special Housing Unit and Health Services.
   d. Priority #1: General Housing Units 1-6.
   e. Priority #1: Food Service.
   f. Priority #1: Shared Warehouse & Garage/Landscape Buildings.
   g. Priority #1: Prison Camp (Housing & Food Service Building).
   h. Priority #1: UNICOR Building (excluding factory).

2.3 GROUNDING

A. The following requirements shall be met:

   1. The switchgear resistance to ground shall not exceed 5 ohms.
   2. The minimum ground grid to switchgear ground connection shall be 4/0 AWG, and also shall be connected to the switchgear ground bus.
   3. The enclosure and noncarrying parts of switchgear shall be bonded together and grounded to the switchgear ground pad with a minimum resistance to ground of 5 ohms, and all connectors shall be exothermically welded in compliance with UL 467.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Factory test equipment prior to delivery.

B. Prior to Substantial Completion, the equipment shall be tested:

   1. To verify switchgear operation according to manufacturer’s recommendations.
   2. Demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall require each item to perform its function not less than three times. Demonstrate that during a power failure, radial loop feeders are brought on line in accordance with the defined requirements. Prepare a written report covering the demonstration performed and results.
   3. Verify that each subsystem of the primary distribution system (generators, medium voltage switchgear, and paralleling switchgear) have been individually tested and are functioning properly.

C. Perform acceptance tests in accordance with:

1. Manufacturer recommendations.
2. NFPA 110 - Emergency and Standby Power Systems, Paragraph 7.13 Installation and Acceptance Test.
3. Demonstrate switchgear capability and compliance according to InterNational Electrical Testing Association (NETA) standards. These standards are listed in NETA “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems” Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Provide a certified inspector’s report.

D. A final acceptance test of the primary system shall be performed prior to substantial completion of the power distribution system.

1. The test shall be scheduled in advance and witnessed by the Contracting Officer (or designated representative).
2. The test shall be witnessed by the Engineer of Record and performed by the Manufacturer’s Representative from each of the following: generator, medium voltage switchgear, and paralleling switchgear.
3. The acceptance test shall consist of the local utility company creating four individual faults (a single phase fault on each one of the incoming phases and a three phase fault) on the incoming utility service. This is to be accomplished by the installation of three load break disconnect switches capable of creating a single phase fault on each phase and a three phase fault.
4. The test shall verify the proper operation of the individual components (generator, paralleling switchgear, and medium voltage switchgear) operating as a whole in accordance with specification requirements. The test includes proper operation during both loss of utility power and restoration of utility power.
5. If the test fails to produce a complete operational system of the standby power generation system (generators, paralleling switchgear, main distribution switchgear, etc) as specified in the design specification and drawings, all costs incurred by repeating the test and repairing/replacing any damaged equipment caused by the initial failed test shall be paid by the Contractor.

END OF SECTION

SECTION 26 11 16
SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes double ended, secondary unit substation, consisting of medium-voltage primary incoming sections, transformer sections, and low-voltage secondary switchboard section, with the following features:

1. Indoor enclosures
2. Medium-voltage, air terminal chambers.
3. Liquid-filled transformers.
4. Tie-Breaker.

B. New substation will replace an existing Square D, Power Zone III substation with bottom feed distribution and the new substation distribution sections shall match the existing bottom feed conduits in order to make a timely replacement with minimum down time. The primary feeders shall be refed overhead.

C. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.
2. Dimensioned plans and elevations showing major components and features.

   a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

3. One-line diagram.
4. Nameplate legends.
5. Short-time and short-circuit current ratings of secondary unit substations and components.
6. Ratings of individual protective devices.

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings for Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Coordination Drawings for Indoor Installations:

1. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
2. Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
3. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
4. Support locations, type of support, and weight on each support.
5. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

C. Qualification Data: For testing agency.

D. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

E. Product certificates.

F. Factory test reports.

G. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA, NRTL, or manufacturer’s Services Division.

1. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

PART 2 - PRODUCTS

2.1 SQUARE D UNIT SUBSTATION WITH CLASS 6037, POWER ZONE 4 SWITCHGEAR

A. Basis-of-Design Product: Subject to compliance with requirements, provide a Unit Substation by Square D as shown on the Drawings, or comparable product by one of the following:

1. Eaton Electrical Inc., Cutler-Hammer Business Unit.
2. ESL Power Systems, Inc.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Siemens Energy
5. Or Equal, as long as the product is compliant with the Buy American Act.

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, primary incoming sections; transformer sections; and low-voltage secondary switchgear section; and including coordinated draw-out circuit breakers, tie-breaker, Surge Protection Device units and metering components.

1. 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.
2. Comply with IEEE C2.
3. Comply with IEEE C37.121.
4. Comply with NFPA 70.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified

2.4 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Single assembly.

2.5 MEDIUM-VOLTAGE TERMINAL COMPARTMENT SECTION

A. Primary Incoming Section: Air terminal chamber.

B. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

C. System Voltage: 13.8 kV nominal; 15 kV maximum.

D. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.6 Not used.

2.7 LIQUID-FILLED TRANSFORMER SECTION

A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, two-winding, secondary unit substation transformer.

B. Insulating Liquid: Mineral oil complying with ASTM D 3487, Type II, and tested according to ASTM D 117.

C. Voltage: 13.8 kV to 277/480 volt, three phase grounded system.

D. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

E. BIL: 95 kV.

F. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

G. Coolant and insulating fluid shall be a listed less-flammable fluid meeting the requirements of National Electric Code Section 450-23 and the requirements of National Electrical Safety Code (IEEE C2-1997), Section 15. The fluid shall have a minimum fire point of 300°C, shall be non-toxic, non-bioaccumulating and biodegradable.

H. Impedance: 5.75 percent, with ANSI tolerances.

I. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Liquid-level gage.
2. Pressure-vacuum gage.
3. Liquid temperature indicator.
4. Drain and filter valves.
5. Pressure-relief device.

2.8 SECONDARY SWITCHGEAR SECTION

A. RATINGS

1. Switchgear shall be designed and built to ANSI C37.20.1 standards and listed to UL1558. Circuit breakers shall be designed and built to ANSI C37.13 and C37.16 and listed to UL1006.
2. Switchgear ampacity shall be 1600A, 2000A, 3200A, 4000A, or 5000A as indicated on the drawings.
3. The short circuit current rating of the switchgear assembly and circuit breakers shall be as follows:

Short Circuit Current Rating			**Short-Time**	**Close & Latch**
240V	**480V**	**600V**	**Rating**	**Rating**
42k	42k	42k	42k	42k
65k	65k	65k	65k	65k
85k	85k	85k	85k	50k
200k	200k	130k	30k min.	22k min.

4. The assembly shall be designed for use on 50Hz or 60Hz electrical systems up to 600V. The assembly shall be properly braced to the ratings of the circuit breakers installed within the assembly.

B. STRUCTURE

1. General

a. Each steel section shall contain one or more individual circuit breakers, or instrumentation compartments, as well as a rear compartment for the bus and outgoing cable connections.
b. A rigid removable steel base channel shall be provided at the front and rear of each section.
c. The exterior finish shall be ANSI 49 medium-light grey.
d. Switchgear lineup shall be provided with an overhead lifting device mounted on top of the switchgear for ease of installation and removal of circuit breakers.
e. Access to rear cable termination compartments shall be by hinged rear doors.

2. Dimensions

a. Section widths shall be 22”, 30”, or 36” wide depending on the size of the circuit breakers being installed in the switchgear.
b. The lineup shall provide adequate wire bending space for main and feeder circuit breakers using up to 750 kcmil wire.
c. Adequate conduit space shall be provided to allow all conductors to exit the structure at the same location.

C. CIRCUIT BREAKER COMPARTMENT

1. Circuit Breakers

a. Each circuit breaker shall be mounted in its own barriered compartment.
b. Feeder circuit breakers rated 2000A or less shall be capable of being mounted in the uppermost compartment without de-rating.
c. The front of the circuit breaker shall protrude through the door of the switchgear allowing access to the circuit breaker controls, indicators and trip unit.
d. The design shall allow for closed door racking in the circuit breaker compartments.
e. Circuit breakers of like frames shall be interchangeable as standard construction.
f. Prepared spaces shall include the racking mechanism, bussing, and secondary contacts as necessary.
g. Circuit breaker and prepared space compartments shall be “keyed” to avoid insertion of circuit breakers with similar dimensions but insufficient interrupting ratings, or incorrect frame sizes into an inappropriate circuit breaker compartment.

2. Secondary Connections

a. All customer secondary control and communications connections shall be made from the front of the switchgear lineup.
b. A dedicated wiring channel accessible from the front shall allow easy access to all control or communications terminations.
c. Control connections shall be standard cage clamp. All control wiring shall No. 14 gauge SIS.
d. Dedicated conduit entry for control wires shall be provided at the top and bottom of each section, and shall be capable of terminating up to four (4) three-quarter (¾) inch conduits and accessible from the front of the switchgear.
e. All interconnections between switchgear sections at shipping splits shall use locking pull-apart type terminal blocks.
f. Secondary and communication wiring shall be securely fastened to the switchgear without the use of adhesive backed wire anchors. Adhesive back fasteners shall only be allowed to aid in wire routing.

3. Instrumentation

a. Where additional space is required for instrumentation, control power transformers, metering, etc., a barriered instrumentation compartment shall be used.
b. The auxiliary instrumentation compartment shall not inhibit the routing of control or communications wires.

D. BUSING AND CABLE COMPARTMENT

1. Busing

a. All vertical and horizontal cross bus shall be rated for the full ampacity of the lineup.
b. All bus joints shall consist of grade 5 hardware and conical washers to withstand mechanical forces exerted during short circuits. All joints shall consist of a minimum of two (2) bolts.
c. Busing shall be plated along its entire length.
d. Busing shall be braced to withstand the instantaneous interrupting rating of the main circuit breakers or 65 kAIR minimum.

2. Cable Compartment

a. All incoming or outgoing power conductors shall be routed through the rear cable compartment.
b. Conduit area for each section shall be a minimum of seventeen (17) inches wide and provide adequate depth for all section conduits.
c. Provide barriers to separate cable compartments from adjacent cable compartments.
d. Minimum conduct area available shall be as follows:

	Section Depth			
Section Width	**54"**	**60"**	**72"**	**80"**
22"	17"W x 8"D	17"W x 14"D	17"W x 26"D	17"W x 34"D
30"	25"W x 8"D	25"W x 14"D	25"W x 26"D	25"W x 34"D
36"	31"W x 8"D	31"W x 14"D	31"W x 26"D	31"W x 34"D

E. LOW VOLTAGE POWER CIRCUIT BREAKERS

1. Circuit Breakers

a. Low voltage power circuit breakers shall be Square D Masterpact NW listed to UL1066 standards.
b. Circuit breakers shall be suitable for the required interrupting capacity without the use of external current limiting fuses.
c. All circuit breakers shall have field interchangeable electrical accessories including shunt trip, auxiliary contacts, electrical operator, shunt close and trip unit.
d. All secondary connections shall be made directly to the front of the circuit breaker cradle.
e. Each circuit breaker shall have built in contact temperature and contact wear sensors.

2. Trip Units

a. Trip units shall have the following Basic trip functions and features:
1) True RMS sensing
2) Adjustable long-time pickup and delay (L)
3) Adjustable short time pickup and delay (S)
4) Adjustable instantaneous pickup (I)
5) Field interchangeable long-time rating plug
6) Long time pickup LED indication.
7) Thermal Memory

b. In addition to the Basic functions listed above, the following Advanced functions and features shall be provided for the Mains and Tie:
1) Adjustable ground fault pickup and delay (G)
2) LED trip indication for LSIG functions
3) Digital Ammeter
4) Phase loading bar graph

3. The following accessories shall be provided for each circuit breaker.

a. Key Interlocks where indicated on the drawings
b. Shunt trip where indicated on the drawings
c. Circuit breaker cell auxiliary switches:
1) 1 N.O. & 1 N.C. for the "Connected" position
2) 1 N.O. & 1 N.C. for the "Test" position
3) 1 N.O. & 1 N.C. for the "Disconnected" position

d. 4 N.O. & 4 N.C. auxiliary contacts
e. Operations counter
f. Electrically operated circuit breaker with status indicating lights where indicated on the drawings.

F. METERING AND INSTRUMENTATION

1. Provide a PowerLogic PM8244 Power Meter where indicated on the drawings.
2. Electronic circuit monitors shall provide true rms metered values. Information provided by each circuit monitor shall include frequency, temperature, current, demand current, voltage, real power, reactive power, apparent power, demand power, predicted demand power, power factor, accumulated energy, accumulated reactive energy, total harmonic distortion (THD) of each current and voltage, and K-factor of each current.
3. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 63rd harmonic, based on fundamental of 60 Hz.
4. All setup parameters required by the Power Meter shall be stored in nonvolatile memory and retained in the event of a control power interruption.
5. The Power Meter shall accept metering inputs of up to 600Vac direct connection or from industry standard instrument transformers, 120 VAC secondary VTs and 5 A secondary CTs. Connection to 480Y/277 VAC circuits shall be possible without use of VTs.
6. The Power Meter shall be accurate to 0.1% of reading plus/minus 0.025% of full scale for voltage and current metering and 0.2% of reading plus 0.025% for power.
7. Not used.
8. Not used.
9. The Power Meter display shall provide local access to the following metered quantities as well as the minimum and maximum value of each instantaneous quantity since last reset of min/max:

a. Current, per phase rms, 3-phase average and neutral (if applicable)
b. Voltage, phase-to-phase, phase-to-neutral, and 3-phase average (phase-to-phase and phase-to-neutral)
c. Real power, per phase and 3-phase total
d. Reactive power, per phase and 3-phase total
e. Apparent power, per phase and 3-phase total
f. Power factor, 3-phase total and per phase
g. Frequency
h. Demand current, per phase and three phase average
i. Demand real power, three phase total
j. Demand apparent power, three phase total
k. Accumulated Energy, (MWh and MVARh)
l. THD, current and voltage, per phase
m. K-factor, current, per phase.

G. SURGE PROTECTION DEVICES (SPD)

1. Provide Square D SURGELOGIC SPD protection mounted in the Service Entrances of switchboard.
2. Design standards.

a. SPD shall be Listed in accordance with UL 1449 Third Edition, Type 2 device and UL 1283, Electromagnetic Interference Filters.
b. Integrated surge protective devices (SPD) shall be Component Recognized in accordance with UL 1449 Third Edition, Section 37.3.2 and 37.4 at the standard's highest short circuit current rating (SCCR) of 200 kA, including intermediate level of fault current testing that will be effective 9/29/2009.

c. SPD shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50µs, 10kA-8/20µs).
d. SPD shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems (7 Mode).
e. The manufacturer of the SPD shall be the same as the manufacturer of the service entrance and distribution equipment in which the devices are installed and shipped.

3. SPD ratings:

a. Minimum surge current rating shall be 240 kA per phase (120 kA per mode for distribution applications.
b. UL 1449 clamping voltage shall not exceed the following: Voltage Protection Rating (VPR).

VOLTAGE	L-N	L-G	N-G
240/120	1200/800V	800V	800V
208Y/120	800V	800V	800V
480Y/277	1200V	1200V	1200V
600Y/347	1500V	1500V	1500V

c. Pulse life test: Capable of protecting against and surviving 5000 ANSI/IEEE Category C High transients without failure or degradation of clamping voltage by more than 10%.
d. Minimum UL 1449 3rd edition withstand Nominal Discharge Current (I_n) rating to be 20kA per mode.
e. SPD shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.

4. SPD shall be constructed of one self-contained suppression module per phase.
5. Visible indication of proper SPD connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.
6. SPD shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.
7. A connector shall be provided along with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate an end-of-life condition for the complete SPD or module.
8. Terminals shall be provided for necessary power and ground connections.
9. The SPD shall be equipped with a transient voltage surge counter located on the diagnostic panel on the front cover of the enclosure. The counter shall be equipped with a manual reset and battery backup to retain memory upon loss of AC power.
10. SPD shall have a warranty for a period of ten (10) years from date of invoice. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by their respective field service division.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with applicable portions of NECA 1, NECA 400, NECA 410, NECA 430, and NEMA SG 11.

B. Install secondary unit substation on existing concrete equipment base. Locate as shown on drawings.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.2 IDENTIFICATION

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

1. Install the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 ft apart.
2. Install arc-flash warning labels specified in Section 260574 "Overcurrent Protective Device Arc-Flash Study."

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. At Exterior Locations:

   a. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals shall directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
   b. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. Bond each gate section to the fence post using 1/8 by 1 inch tinned flexible braided copper strap and clamps.
   c. Make joints in grounding conductors and loops by exothermic weld or compression connector.

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

3.4 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B Ch. "Testing and Test Methods."
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:

    a. Verify equipment nameplate data complies with Contract Documents.
    b. Inspect bolted electrical connections for high resistance using one of the following two methods:

        1) Use a low-resistance ohmmeter to 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 according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

C. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, grounding, and required area clearances.
    c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
    d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as the address of the circuit breaker that is used to identify it in microprocessor-communication software.
    e. Verify that current and voltage-transformer ratios correspond to Drawings.
    f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

        1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
        2) Make key exchange with devices operated in off-normal positions.

    g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    h. Inspect insulators for evidence of physical damage or contaminated surfaces.
    i. Verify correct barrier and shutter installation and operation.
    j. Exercise all active components.
    k. Inspect mechanical indicating devices for correct operation.
    l. Verify that filters are in place and vents are clear.

m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-use or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

c. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

d. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

e. Verify operation of space heaters.
f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Verify correct connection of transformers with system requirements.

c. Verify that adequate clearances exist between primary and secondary circuit wiring.
d. Verify the unit is clean.
e. Verify that all required grounding and shorting connections provide contact.
f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall comply with IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or shall comply with IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute according to NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS, Table 100.5. Insulation-resistance values of the transformers shall not be less than values shown in NETA ATS, Table 100.5
c. Perform a polarity test on each transformer to verify the polarity marks or H(1)- X(1) relationship. Polarity results shall agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors shall not exceed the tolerances specified in IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.
g. Not used.

E. Liquid-Filled Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect impact recorder prior to unloading.
c. Test dew point of tank gases if applicable.
d. Inspect anchorage, alignment, and grounding.
e. Verify the presence of PCB content labeling.
f. Verify removal of any shipping bracing after placement.
g. Verify the bushings are clean.
h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
k. Perform specific inspections and mechanical tests recommended by the manufacturer.
l. Verify presence of transformer surge arresters and that their ratings are as specified.
m. Verify that as-left tap connections are as specified.
n. Verify the presence of surge arresters and that their ratings are as specified.
o. Not used

F. Insulated-Case/Molded-Case Air-Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage and alignment.
c. Verify the unit is clean.
d. Operate the circuit breaker to ensure smooth operation.
e. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
f. Perform adjustments for final protective-device settings according to the coordination study. Set the protective devices according to results in Section 260573 "Overcurrent Protective Device Coordination Study" and in Section 260574 "Overcurrent Protective Device Arc-Flash Study."

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
b. Perform a contact/pole-resistance test. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Determine long-time pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band, including adjustment factors.
d. Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
e. Determine ground-fault pickup and time delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

f. Determine instantaneous pickup by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
g. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
h. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.
i. Verify operation of charging mechanism. The charging mechanism shall operate according to manufacturer's published data.

G. Low-Voltage Ground-Fault Protection System Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect the components for damage and errors in polarity or conductor routing.

1) Verify that ground connection is made on the source side of the neutral disconnect link and on the source side of any ground-fault sensor.
2) Verify that the neutral sensors are connected with correct polarity on both primary and secondary.
3) Verify that phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
4) Verify that grounding conductors do not pass through zero sequence sensors.
5) Verify that grounded conductor is solidly grounded.

b. Verify the unit is clean.
c. Operate the circuit breaker to ensure smooth operation.
d. Verify correct operation of functions of the self-test panel if provided.
e. Verify that the control power transformer has adequate capacity for the system.
f. Set pickup and time-delay settings according to "Quality Control" Article. Record appropriate operation and test sequences according to NFPA 70, "Services" Article, "Ground-Fault Protection Equipment" Section.

2. Electrical Tests:

a. Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace the neutral disconnect link after testing. System neutral-to-ground insulation resistance shall be a minimum of one megohm. Correct wiring until the minimum is achieved.
b. Perform ground-fault protective-device pickup tests using primary injection. Results of pickup test shall be greater than 90 percent of the ground-fault protective-device pickup setting and less than 1200 A or 125 percent of the pickup setting, whichever is smaller. Adjust or replace the device until these parameters are achieved.
c. For summation-type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current-transformer pair. This test also applies to MCCBs utilizing an external neutral current transformer. The ground-fault protective device shall operate when current direction is the same relative to polarity marks in the two current transformers. The ground-fault protective device shall not operate when current direction is opposite relative to polarity marks in the two current transformers.
d. Measure time delay of the ground-fault protective device at a value equal to or greater than 150 percent of the pickup value. Relay timing shall be according to manufacturer's

published data but shall be no longer than one second at 3000 A according to NFPA 70, "Services" Article, "Ground-Fault Protection Equipment" Section.

e. Verify reduced control voltage tripping capability is 55 percent for ac systems and 80 percent for dc systems. Replace the ground-fault system if the reduced control voltage tripping requirement is not achieved, and retest.

f. Verify blocking capability of zone interlock systems. Results of zone-blocking tests shall be according to manufacturer's published data and design specifications.

H. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.

c. Verify the unit is clean.

d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.

b. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.

c. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.

d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Distribution, dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Acme Electric Corporation.

2. Eaton.
3. General Electric Company.
4. Lincoln Electric Products Co., Inc.
5. Siemens Power Transmission & Distribution, Inc.
6. Square D; by Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

1. Coil Material: Copper.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2 Core and coil shall be encapsulated within resin compound to seal out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

F. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of **150**-deg C rise above 40-deg C ambient temperature.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: Manufacturer's standard brackets.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

B. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

D. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

F. Construct concrete bases according to Division 03 and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

G. Secure transformer to concrete base according to manufacturer's written instructions.

H. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

I. Remove shipping bolts, blocking, and wedges.

3.2 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. 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.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3.4 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

A. MCCB: Molded-case circuit breaker.

B. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard schedules for installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.7 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: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

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. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

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.

F. Incoming Mains Location: Convertible between top and bottom.

G. Phase, Neutral, and Ground Buses Hard-drawn copper, 98 percent conductivity.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
3. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

I. NRTL Label: Panelboards 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 shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. 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.

L. 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.

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. Eaton.
2. ESL Power Systems, Inc.
3. General Electric Company; GE Energy Management - Electrical Distribution.
4. Siemens Energy
5. Square D; a brand of Schneider Electric.

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. – See Drawings

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

G. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. External Control-Power Source: 120-V branch circuit

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; a brand of Schneider Electric

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. External Control-Power Source: 120-V branch circuit.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.

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. 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 fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting 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. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
i. 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 26 28 13 "Fuses."

2.6 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 transparent card holder.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. 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 INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NECA 407.

C. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Mount top of trim 90 inches above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box.

F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. 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.

I. Install filler plates in unused spaces.

J. 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.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems" identifying source of remote circuit.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA Acceptance Testing Specification. 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.

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.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Straight-blade convenience receptacles.
2. GFCI receptacles.
3. SPD receptacles.
4. Toggle switches.
5. Wall switch sensor light switches with dual technology sensors.
6. Wall plates.

1.2 DEFINITIONS

A. Abbreviations of Manufacturers' Names:

1. Cooper: Copper Wiring Devices; Division of Cooper Industries, Inc.
2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
3. Leviton: Leviton Mfg. Company, Inc.
4. Pass & Seymour: Pass& Seymour/Legrand.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPTACLES

A. Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2.3 GFCI RECEPTACLES

A. General Description:

1. 125 V, 20 A, straight blade, non-feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

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

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Pass & Seymour/Legrand (Pass & Seymour).

2.4 SPD RECEPTACLES

A. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 1449, and FS W-C-596, with integral SPD in line to ground, line to neutral, and neutral to ground.

1. 125 V, 20 A, straight blade type.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

B. Duplex SPD Convenience Receptacles:

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

   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Straight blade, 125 V, 20 A; NEMA WD 6 Configuration 5-20R.

C. Isolated-Ground Duplex SPD Convenience Receptacles:

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

   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description:

   a. Straight blade, 125 V, 20 A; NEMA WD 6 Configuration 5-20R.
   b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Single Pole:

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

      1) Eaton (Arrow Hart).
      2) Hubbell Incorporated; Wiring Device-Kellems.
      3) Leviton Manufacturing Co., Inc.
      4) Pass & Seymour/Legrand (Pass & Seymour).

2. Two Pole:

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

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.
4) Pass & Seymour/Legrand (Pass & Seymour).

3. Three Way:

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

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.
4) Pass & Seymour/Legrand (Pass & Seymour).

4. Four Way:

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

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.
4) Pass & Seymour/Legrand (Pass & Seymour).

C. Pilot-Light Switches, 120/277 V, 20 A:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Single pole, with LED-lighted handle, illuminated when switch is off.

D. Key-Operated Switches, 120/277 V, 20 A:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.

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

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

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

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

2.6 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.7 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Ivory or White As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. SPD Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

B. Wall Plate Color: Stainless Steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. GFCI Receptacles: Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.2 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:

1. Tests for Convenience Receptacles:

a. Line Voltage: Acceptable range is 105 to 132 V.
b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
c. Ground Impedance: Values of up to 2 ohms are acceptable.
d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
e. Using the test plug, verify that the device and its outlet box are securely mounted.
f. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

SECTION 26 28 13
FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Enclosed controllers.
c. Enclosed switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bussmann, an Eaton business.
2. Edison; a brand of Bussmann by Eaton.
3. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay. rejection type
2. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.2 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 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."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. ABB Inc.
2. Eaton.
3. General Electric Company.
4. Siemens Industry, Inc.
5. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified rejection type fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified rejection type fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. 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. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc.
4. Square D; a brand of Schneider Electric

B. Type GD, General Duty, Single Throw, 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.

C. Type HD, Heavy Duty, Six Pole, Single Throw, 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. 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. Lugs: Suitable for number, size, and conductor material.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.2 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "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.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

SECTION 26 29 13
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.
3. Multispeed.

1.2 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers 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."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

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

a. Eaton.
b. General Electric Company.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc.
e. Square D: a brand of Schneider Electric.

2. Configuration: Non reversing and Two speed.
3. Surface mounting.
4. Pilot light.

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

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

a. Eaton.
b. General Electric Company.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc.
e. Square D: a brand of Schneider Electric.

2. Configuration: Non reversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Surface mounting.
5. Pilot light.

D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

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

    a. Eaton.
    b. General Electric Company.
    c. Rockwell Automation, Inc.
    d. Siemens Industry, Inc.
    e. Square D: a brand of Schneider Electric

2. Configuration: Non reversing Reversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type.
4. Surface mounting.
5. Pilot light.

E. Magnetic Controllers: Full voltage, across the line, electrically held.

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

    a. Eaton.
    b. General Electric Company.
    c. Rockwell Automation, Inc.
    d. Siemens Industry, Inc.
    e. Square D: a brand of Schneider Electric.

2. Configuration: Non reversing.
3. Contactor Coils: Pressure-encapsulated type.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
6. Melting Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

7. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

8. Solid-State Overload Relay:

   a. Switch or dial selectable for motor running overload protection.
   b. Sensors in each phase.
   c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

9. External overload reset push button.

F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

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

   a. Eaton.
   b. General Electric Company.
   c. Rockwell Automation, Inc.
   d. Siemens Industry, Inc.
   e. Square D: a brand of Schneider Electric.

2. Fusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
4. Nonfusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

5. MCP Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.

6. MCCB Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
   b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

2.2 MULTISPEED MAGNETIC CONTROLLERS

A. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.

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

   a. Eaton.
   b. General Electric Company.
   c. Rockwell Automation, Inc.
   d. Siemens Industry, Inc.
   e. Square D: a brand of Schneider Electric

2. Configuration: Non reversing.
3. Contactor Coils: Pressure-encapsulated type.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 24 -V ac; obtained from integral CPT, with primary and secondary fuses of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
6. Compelling relays shall ensure that motor will start only at low speed.
7. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
8. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
9. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
10. Melting Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

11. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

12. Solid-State Overload Relay:

    a. Switch or dial selectable for motor running overload protection.
    b. Sensors in each phase.
    c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

13. External overload reset push button.

C. Combination Multispeed Magnetic Controller: Factory-assembled combination of multispeed magnetic controller, OCPD, and disconnecting means.

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

a. Eaton.
b. General Electric Company.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc.
e. Square D: a brand of Schneider Electric.

2. Fusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

3. Nonfusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

4. MCP Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.

5. MCCB Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
e. N.C. alarm contact that operates only when MCCB has tripped.

2.3 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 4X.
3. Wash-Down Areas: Type 4X stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.4 ACCESSORIES

A. Push Buttons, Pilot Lights, and Selector Switches: NEMA ICS 5; heavy-duty type; factory installed in controller enclosure cover unless otherwise indicated.

B. Control Relays: Auxiliary and adjustable time-delay relays.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height, and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch enclosed controller.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13 "Fuses."

G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Section 26 05 23 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and overload-relay pickup and trip ranges.

B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

SECTION 26 32 00
PACKAGED GENERATOR ASSEMBLIES

PART 1 - GENERAL

1.1 COORDINATION

A. Coordinate with the following Specification Sections:

1. 23 11 13 - FACILITY FUEL-OIL PIPING.
2. 26 10 00 - PARALLELING SWITCHGEAR
3. 26 11 16 - SECONDARY UNIT SUBSTATIONS

1.2 REFERENCES

A. Standards - The design and construction of the facility shall comply with the following:

1. International Electrical Testing Association (NETA) - ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
2. NFPA 110 - Emergency and Standby Power Systems

1.3 SUBMITTALS

A. Inspection and test reports.

1.4 WARRANTY

A. Two Year Standby (ISO 8528-1: ESP) Generator Set Warranty. The manufacturer's standard warranty shall in no event be for a period of less than two (2) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall be limited to 500 hours annually for the system warranty by both the manufacturer and servicing distributor. Submittals received without written warranties as specified will be rejected in their entirety.

1.5 SYSTEM DESCRIPTION

A. Operation:

1. Provide standby power generation equipment to function as an alternate electrical source for the institution in the event of a utility service interruption. The generation equipment shall not be used for peak shaving or similar applications.
2. Generator set shall be standby-rated, 15 kV class, 3-phase, 3-wire, 60 hertz, including radiator fan and all parasitic loads. Generator feeds paralleling and synchronizing switchgear. See Section 26 10 00 - PARALLELING SWITCHGEAR for specific switchgear requirements. The distribution of emergency power shall be through the institution's medium voltage primary distribution.
3. In the event of utility power failure, the paralleling switchgear will automatically bring the generators on line and transfer the primary electrical power source from the local utility company to the generators. Upon sensing restoration of normal utility power, the paralleling switchgear will automatically transfer loads to the utility source and initiate a generator cool-down and shut off cycle.

B. Capacity:

1. Provide one (1) 100% capacity, diesel engine generator. Refer to: PARTIAL ELECTRICAL ONE-LINE DIAGRAM (LOW PRISON) – NEW WORK. The generator shall be required to serve 100% of the institution's operating electrical load.
2. Generator sizing has been based on Peak Demand loads provided by the Utility to the FBOP.

1.6 EXTRA MATERIALS

1.7 FUSES

A. Provide six of each type and rating used. Include spares for fusible devices. Fuses shall match type installed and be packaged with protective covering for storage and identified UNIT SUBSTATION with labels describing contents.

PART 2 - PRODUCTS

2.1 DIESEL ENGINE DRIVEN GENERATOR

A. Basis-of-Design Product: Subject to compliance with requirements, provide a Generator by Cummins, Inc. as shown on the drawings, or comparable product by one of the following:

1. Cummins
2. Kohler (MTU Engine Only)
3. Caterpillar
4. Or Equal, as long as the product is compliant with the Buy American Act.

2.2 ENGINE

A. The engine shall be water cooled in line or vee-type, four (4)-cycle, compression ignition diesel. It shall meet specifications when operating on Ultra Low Sulphur Diesel (ULSD). Two cycle engines will not be considered. Equip engine with fuel, lube oil and intake air filters, lube oil cooler, fuel transfer pump, fuel priming pump, service meter, gear-driven water pump.

B. The engine governor shall be an electronic speed control. Speed droop shall be externally adjustable from 0 (isochronous) to 10% from no load to full rated load. Steady state frequency regulation shall be +/- 0.25 percent. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear.

C. The engine shall utilize a gear-type, positive displacement, full pressure lubricating oil pump and water cooled lube oil cooler. Pistons shall be spray-cooled. Provide oil filters, oil pressure gauge, dipstick and oil drain.

2.3 GENERATOR

A. The synchronous three-phase generator shall be a two bearing, self-ventilated, drip-proof design in accordance with NEMA MG 1 and directly connected to the engine flywheel housing with a closed coupling.

B. The self-excited, brushless, permanent magnet exciter shall consist of a three-phase armature and a three-phase full wave bridge rectifier mounted on the rotor shaft. Include surge suppression to protect the diodes from voltage spikes.

C. Size the generators to minimize harmonic content per IEEE 519. Use a 2/3 pitch factor to eliminate all tripen harmonics.

D. Design the transient response so that momentary overloads do not cause an individual generator to shut down.

E. The digital automatic voltage regulator (D-AVR) shall maintain generator output voltage within +/- 0.5 percent for any constant load between no load and full load. The regulator shall be a totally solid state design, which includes electronic voltage buildup, volts per Hertz regulation, three phase sensing, over excitation protection, loss of sensing protection, temperature compensation, shall limit voltage overshoot on startup, and shall be environmentally sealed.

F. The alternator shall produce a voltage waveform with not more than 5% total harmonic distortion (line to neutral), with a maximum of 3% distortion in any one harmonic order.

G. Provide a sub-transient reactance of 0.12 per unit or lower in order to minimize the effects of the instantaneous response of an alternator to a large overload (non-linear loads or motor starting).

2.4 CONTROLS

A. Provide a generator mounted interface panel for complete control and monitoring of the engine and generator set functions in accordance to NFPA 110 Level 1 from the Paralleling Switchgear.

B. Provide a remoted status, to a monitor located in the Utility Building Operator’s Office. The panel shall annunciate the following:

1. Utility power status (On/Off).
2. Generator power status (On/Off).
3. Generator alarm condition.
4. Total facility amperage usage (provide analog type meter).
5. Audible trouble alarm with alarms silencing switch and automatic ring-back feature.

C. Controls – Generator Set Mounted:

1. Provide a fully solid-state, microprocessor based, generator set control. The control panel shall be designed and built by the engine manufacturer. The control shall provide all operating, monitoring, and control functions for the generator set. The control panel shall provide real time digital communications to all engine and regulator controls via SAE J1939.

D. Environmental

1. The generator set control shall be tested and certified to the following environmental conditions:

a. –40°C to +70°C Operating Range
b. 95% humidity non-condensing, 30°C to 60°C
c. IP22 protection
d. 5% salt spray, 48 hours, +38°C, 36.8V system voltage
e. Sinusoidal vibration 4.3G's RMS, 24-1000Hz
f. Electromagnetic Capability (89/336/EEC, 91/368/EEC, 93/44/EEC, 93/68/EEC, BS EN 50081-2, 50082-2)
g. Shock: withstand 15G

E. Functional Requirements

1. The following functionality shall be integral to the control panel:

a. The control shall include a graphical display with text based alarm/event descriptions
b. The control shall include a minimum of 3-line data display
c. Audible horn for alarm and shutdown with horn silence switch
d. Standard ISO labeling
e. Multiple language capability

f. Remote start/stop control
g. Local run/off/auto control integral to system microprocessor
h. Cooldown timer
i. Speed adjust
j. Lamp test
k. Push button emergency stop button
l. Voltage adjust
m. Voltage regulator V/Hz slope - adjustable
n. Password protected system programming

F. Digital Monitoring Capability. The controls shall provide the following digital readouts for the engine and generator. All readings shall be indicated in either metric or English units.

1. Engine:

a. Engine oil pressure
b. Engine oil temperature
c. Engine coolant temperature
d. Engine RPM
e. Battery volts
f. Engine hours
g. Engine crank attempt counter
h. Engine successful start counter
i. Real time clock

2. Generator:

a. Generator AC volts (Line to Line, Line to Neutral and Average)
b. Generator AC current (Avg and Per Phase)
c. Generator AC Frequency
d. Generator kW (Total and Per Phase)
e. Generator kVA (Total and Per Phase)
f. Generator kVAR (Total and Per Phase)
g. Power Factor (Avg and Per Phase)
h. Total kW-hr
i. Total kVAR-hr
j. % kW
k. % kVA
l. % kVAR

3. Voltage Regulation:

a. Excitation voltage
b. Excitation current

G. Alarms and Shutdowns. The control shall monitor and provide alarm indication and subsequent shutdown for the following conditions. All alarms and shutdowns are accompanied by a time, date, and engine hour stamp that are stored by the control panel for first and last occurrence:

1. Engine Alarm/Shutdown:

a. Low oil pressure alarm/shutdown
b. High coolant temperature alarm/shutdown
c. Loss of coolant shutdown
d. Overspeed shutdown

e. Overcrank shutdown
f. Emergency stop depressed shutdown
g. Low coolant temperature alarm
h. Low battery voltage alarm
i. High battery voltage alarm
j. Control switch not in auto position alarm
k. Battery charger failure alarm

2. Generator Alarm/Shutdown:

a. Generator over voltage
b. Generator under voltage
c. Generator over frequency
d. Generator under frequency
e. Generator reverse power
f. Generator overcurrent

3. Voltage Regulator Alarm/Shutdown:

a. Loss of excitation alarm/shutdown
b. Instantaneous over excitation alarm/shutdown
c. Time over excitation alarm/shutdown
d. Rotating diode failure
e. Loss of sensing
f. Loss of PMG

H. Inputs and Outputs

1. Programmable Digital Inputs:

a. The Controller shall include the ability to accept six (6)eighteen (18) programmable digital input signals. The signals may be programmed for either high or low activation using programmable Normally Open or Normally Closed contacts.

2. Digital Outputs:

a. The control shall include the ability to operate six (6) programmable relay output signals, integral to the controller. The output relays shall be rated for 2A @ 30VDC and consist of six (6) Form A (Normally Open) contacts and two (10) Form C (Normally Open & Normally Closed) contacts.

3. Discrete Outputs:

a. The control shall include the ability to operate two (2) discrete outputs, integral to the controller, which are capable of sinking up to 300mA.

I. Maintenance

1. All engine, voltage regulator, control panel and accessory units shall be accessible through a single electronic service tool. The following maintenance functionality shall be integral to the generator set control:

a. Engine running hours display

b. Engine crank attempt counter
c. Engine successful starts counter
d. 20 events are stored in control panel memory
e. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

1) Day of week
2) Time of day to start
3) Duration of cycle

J. Remote Communications (Located in paralleling switchgear)

1. Remote Communications:

a. The control shall include Modbus RTU communications as standard via RS-485 half duplex with configurable baud rates from 2.4k to 57.6k.

K. Local and Remote Annunciation

1. Local Annunciator (NFPA 99/110, CSA 282)
2. Provide a local, control panel mounted, annunciator to meet the requirements of NFPA 110, Level 1.

a. Annunciators shall be networked directly to the generator set control.
b. Local Annunciator shall include a lamp test pushbutton, alarm horn and alarm acknowledge pushbutton.
c. Provide the following individual light indications for protection and diagnostics:

1) Overcrank
2) Low coolant temperature
3) High coolant temperature warning
4) High coolant temperature shutdown
5) Low oil pressure warning
6) Low oil pressure shutdown
7) Overspeed
8) Low coolant level
9) EPS supplying load
10) Control switch not in auto
11) High battery voltage
12) Low battery voltage
13) Battery charger AC failure
14) Emergency stop
15) Spare
16) Spare

L. Remote Annunciator (NFPA 99/110, CSA 282)

1. Provide a remote annunciator to meet the requirements of NFPA 110, Level 1.

a. The annunciator shall provide remote annunciation of all points stated above and shall incorporate ring-back capability so that after silencing the initial alarm, any subsequent alarms will sound the horn.
b. Ability to be located up to 800 ft from the generator set

c. Remote annunciator will be located in the paralleling switchgear and will be transmitted by the radio system to the existing Maintenance Office.

2.5 COOLING SYSTEM

A. Provide unit mounted radiator using 50% Ethylene/Propylene Glycol and 50% water cooled.

B. Provide radiators with sufficient capacity to maintain safe engine operation up to a temperature of 43.3 degrees C at the fan at an elevation of 152 m. Equip the radiator with a galvanized steel expansion tank, mounted on top of the radiator structure, with a capacity of at least 15% of the cooling system fluid volume. Provide a sight glass on the expansion tank for ease of checking the coolant level. Equip the expansion tank with a low water level alarm/shutdown switch to ensure minimum coolant level. Provide a generator mounted interface panel for complete control and monitoring of the engine and generator set functions in accordance to NFPA 110 Level 1 from Paralleling Switchgear.

2.6 WEATHER ENCLOSURE

A. A weather protective enclosure shall be provided which allows the generator set to operate at full rated load with a static pressure drop less than 0.5 inches of water. The exhaust system shall be internal to the enclosure.

B. The enclosure shall be constructed of 12 gauge galvannealed steel outer skin with stiffeners, 12 gauge galvannealed steel skin roof with stiffeners and framing, 22 gauge perforated galvanized steel inner skin. The enclosure framing shall consist of A-36 structural steel tubing and channel members. The enclosure roof shall be pitched to prevent water accumulation.

C. A radiator discharge elbow shall be provided to direct the radiator air vertically. The elbow shall include a side access hatch for clean out and bird screen at the top. An internal turning vane shall be supplied to assist with the discharge airflow. The discharge duct assembly shall extend to the top of the roof section. The elbow assembly shall be fabricated from 7 gauge material with support angle.

D. Doors shall be 12-gauge galvanealed steel construction painted to match the enclosure exterior and incorporated into 12-gauge galvanealed steel frames that are structurally integrated into the enclosure wall. The doors shall include the following:
   a. Restraint/Hold back hardware to prevent door to keep door open at 180 degrees during maintenance.
   b. Door hardware shall include 304 S.S. leaf hinges, chrome plated refrigerator type latches with inside release, and S.S. bolting hardware. The inside release shall allow escape from within when locked externally.
   c. Rain lip over all doors

E. The enclosure shall be provided with the following:
   a. Exhaust opening with stainless steel weather shield
   b. Inlet and discharge weather louvers with birdscreen which aid in the dispersion and removal of water from the air stream
   c. Lifting lugs for lifting of the main enclosure and roof section only

F. General enclosure design will be able to withstand the following loadings: 125 mph winds, 42 lbs/sq. ft. roof loads, rain resistant to 4” per hour, and maximum static pressure drop less than 0.5 inches of water through the enclosure.

G. Enclosure electrical package shall include:
   a. AC Load Panel (Square D)
   b. Optional 15-30 kVA 1 or 3 phase mini-power zone (Square D)
   c. Interior lighting: Four "TA" fluorescent light fixtures with two 4 foot bulbs wired to AC panel
   d. Two light switches
   e. Two 20 Amp GFCI duplex receptacles

H. All generator auxiliary loads shall be wired to the AC load panel for customer connection via EMT galvanized conduit with EMT connections. All electrical shall be rated weather tight.

I. Finish: Enclosures exterior surfaces shall be cleaned, primed and painted with one coat of epoxy and one coat of polane polyurethane.

2.7 FUEL SYSTEM

A. Provide a primary fuel filter/water separator in the fuel inlet line to the engine in addition to the standard fuel filters provided by the engine manufacturer. All fuel piping shall be black iron or flexible fuel hose rated for 149 degree C and 7 kg/cm. No galvanized piping will be permitted.

B. Provide a 660 Gallon subbase day tank per generator. Day tank installations shall be complete and functional with necessary motors, fuel oil coolers, valves, alarms and pumps. The day tank shall be double-walled construction. Provide dual pumping system and controls. Size pumps to transfer fuel from the storage tank to the day tank and meet the system demand.

2.8 EXHAUST SYSTEM

A. Provide a critical grade exhaust silencer. Size to ensure a minimum A-weighted exhaust sound pressure insertion loss of 33 dBa,. The exhaust back pressure loss through the silencer is not to exceed the engine specifications.

2.9 STARTING SYSTEM

A. Starting Motor - Provide with a dual DC starting system with positive engagement.

2.10 JACKET WATER HEATER

A. Provide with a unit mounted jacket water heater. Size the jacket water heater to maintain water temperature at 32.2 degrees C in an ambient temperature of minus 17.7 degrees C.

2.11 BATTERIES

A. Provide a heavy-duty diesel starting type lead-acid storage battery. Battery voltage shall be compatible with the starting system. The battery set shall be rated no less than 172 amperes-hours. Provide necessary cables and clamps.

B. Battery Trays - Provide a battery tray for the batteries in accordance to NEC 480-7(b). Treat trays to be resistant to deterioration by battery electrolyte. Further, construction shall be such that any spillage or boil-over battery electrolyte shall be contained within the tray to prevent a direct path to ground.

C. Install equipment in accordance with manufacturer's recommendations, the project drawings and specifications, and all applicable codes. Serve all equipment necessary for the proper operation of the generators, such as fuel pumps and exhaust fans from a standby power source.

2.12 BATTERY CHARGERS

A. Provide a current limiting battery charger to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. Provide charger with overload protection, silicone diode full wave rectifiers, voltage surge suppressor, DC ammeter, DC voltmeter, and fused AC input. AC input voltage shall be 120 volts, single phase. Provide charger with LED annunciation for low DC volts, loss of AC power, and high DC volts. Maintain output amperage of less than 20 amps. Wall mount charger in NEMA 1 enclosure.

PART 3 - EXECUTION

3.1 AIR INTAKE

A. All fresh air intake dampers shall be designed to fail open.

3.2 FIELD QUALITY CONTROL

A. Factory test each generator set prior to delivery.

B. Prior to Substantial Completion, the power generator equipment shall be tested:

1. To verify independent operation of each generator according to manufacturer's recommendations.
2. As a complete system in conjunction with paralleling switchgear, primary distribution switchgear and remote status annunciator panels. Coordinate with Specification Sections 26 10 00 - PARALLELING SWITCHGEAR for testing procedures.

C. Perform acceptance tests in accordance with:

1. Manufacturer recommendations.
2. NFPA 110 - Emergency and Standby Power Systems, paragraph 7.13 Installation and Acceptance Test.
3. International Electrical Testing Association (NETA), paragraph 7.22.1 Emergency Systems - Engine Generator.

D. Provide services of factory-trained personnel to assist in the installation and start-up of the standby power plant. Allow in bid for such services of at least sixteen (32) hours on site time to provide assistance as defined in the Section 3. Services may be split in two visits.

E. Supervised Adjusting and Pre-testing Factory-trained technician and General Contractor shall initially start up the generator with no load in the presence of Owner's inspector only. Engineer's presence will not be required for the initial startup. Record no load genset parameters and proceed with field testing. Factory tech shall perform tests of all system functions, operations, and protective features. Adjust the equipment to ensure operation is according to Specifications:

1. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications (by factory tech).

2. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks (by factory tech).
3. Voltage and Frequency Transient Stability Test: Use a laptop with specialized software to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
4. Any other generator tests and checkup procedures as specified by the factory.
5. General Contractor shall perform noise tests as follows:
6. Generator Noise Tests: Measure noise levels 23 feet away from the generator at 8 locations 45 degrees apart. Record noise levels for all eight locations.
7. Retest and correct deficiencies identified by tests and observations and retest until specified requirements are met.

F. Generator shall be shipped from the factory with the successfully completed and certified 2-hour full load testing at the rated power factor, using reactive load at the site, after field testing, generator supplier shall perform acceptance test per NFPA 110 in the presence of the Owner and the Engineer as follows:

1. A load shall be applied for a four-hour, full-load test. The building load shall be permitted to serve as part of the load supplemented by a resistive load bank of sufficient size to provide a load equal to 100 percent of the nameplate rating of the generator, less applicable derating factors for site condition. Combination of reactive and resistive load testing with power factor close to 1.0 will be allowed at the site provided that rated load tests at rated power factor have been performed and certified by the manufacturer prior to shipment. For medium voltage application the supplier or contractor shall include a temporary transformer if needed to accomplish load tests at rated voltage.
2. If the permanent load bank is not installed, a load bank for the acceptance test shall be furnished by the generator supplier at no cost to the Owner.
3. Building load that can be applied will vary depending on the system demand at the time of the testing. The size of the supplemental load to be provided by the load bank shall be coordinated with the Engineer and the Owner at least 10 days prior to testing.
4. Site acceptance test must confirm that generator produces output as declared by specification, has satisfactory engine and alternator parameters, no signal faults or breaker tripping, and that the auxiliary support systems perform satisfactorily when the generator set operates at full load. These auxiliary systems include: fuel supply and delivery, intake air, exhaust air, ventilation, and cooling system.
5. All recorded values shall be logged in start-up notebook, verified and signed by the field technician who performs the test.
6. The generator contractor is responsible for furnishing all fuel required for start-up and testing and shall leave the tanks full at the completion of the project.

G. The remote generator control system and status panel, located as shown on the Drawings, will be transmitted over the Bureau of Prisons secure network. This work will require a design submittal of all proposed installations, including software to be installed. Design submittal is required to be approved by the facility IT Security prior to starting any work.

H. The touch screen control system shall be approved by BOP Maintenance personnel as user friendly and easy to use. Provide an additional 16 hours and two trips to the site to ensure that the personnel monitoring and utilizing the system are fully trained to utilize the capabilities of the installed system.

END OF SECTION

SECTION 26 43 00
TRANSIENT VOLTAGE SUPPRESSION

PART 1 - GENERAL

1.1 COORDINATION

A. Coordinate with the following Sections:

1. 26 11 16 – SECONDARY UNIT SUBSTATIONS.
2. 26 10 00 – PARALLELING SWITCHGEAR.
3. 26 24 16 - PANELBOARDS

1.2 SYSTEM DESCRIPTION

A. Provide transient voltage surge suppression at the main electrical distribution equipment (at the Secondary Unit Substation and at Panelboards) for new building.

B. See Section 26 10 00 – PARALLELING SWITCHGEAR for transit voltage surge suppression at the medium voltage (15kV) switchboard.

1.3 SUBMITTALS

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

B. Field quality-control reports.

C. Operation and maintenance data.

D. Warranties: Sample of special warranties.

1.4 QUALITY ASSURANCE

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

B. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

C. Comply with UL 1283 and UL 1449- Third Edition or most recent edition.

D. Comply with NFPA 70.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE SUPPRESSORS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Current Technology; Thomas & Betts Power Solutions
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Siemens Energy & Automation, Inc.
5. Square D; a brand of Schneider Electric.
6. Advanced Protection Technologies, Inc.

B. Surge Protection Devices:

1. Non-modular.
2. LED indicator lights for power and protection status.
3. Comply with UL 1449- Third Edition or most recent edition.
4. UL labeled with 200kA Short Circuit Current Rating (SCCR). Fuse ratings are not to be considered in lieu of demonstrated withstand testing of SPD, per NEC 285.6.
5. Fabrication using bolted compression lugs for internal wiring.
6. Integral disconnect switch.
7. Redundant suppression circuits.
8. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
9. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
10. LED indicator lights for power and protection status.
11. UL labeled as Type 1 (verifiable at UL.com)
12. UL labeled with 20kA I nominal (l-n), which is verifiable at UL.com.

C. Peak Single-Impulse Surge Current Rating: 150 kA per mode/300kA per phase.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.

E. Protection modes and UL 1449 VPR for 240/120 V, single-phase, 3-wire circuits shall be as follows:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.

F. Protection modes and UL 1449 VPR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

1. Line to Neutral: 700 V, 1200 V from high leg.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.

G. Protection modes and UL 1449 VPR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 3000 V for 480 V or 1500 V for 240 V.
2. Line to Ground: 1800 V for 480 V or 1200 V for 240 V.

2.2 PANELBOARD SUPPRESSORS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Current Technology; Thomas & Betts Power Solutions
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Siemens Energy & Automation, Inc.
5. Square D; a brand of Schneider Electric.
6. Advanced Protection Technologies, Inc.

B. Surge Protection Devices:

1. Non-modular.
2. LED indicator lights for power and protection status.
3. Comply with UL 1449- Third Edition or most recent edition.
4. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR). Fuse ratings shall not be considered in lieu of demonstrated withstand testing of SPD, per NEC 285.6.
5. Fabrication using bolted compression lugs for internal wiring.
6. Integral disconnect switch, if no breaker is available.
7. Redundant suppression circuits.
8. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
9. LED indicator lights for power and protection status.
10. SPD shall be UL labeled as Type 1 (verifiable at UL.com)
11. UL labeled with 20kA I nominal (l-n) which is verifiable at UL.com.

C. Peak Single-Impulse Surge Current Rating: 50 kA per mode/100 kA per phase.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.

E. Protection modes and UL 1449 VPR for 240/120-V, single-phase, 3-wire circuits shall be as follows:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.

F. Protection modes and UL 1449 VPR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

1. Line to Neutral: 700 V, 800 V from high leg.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.

G. Protection modes and UL 1449 VPR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 3000 V for 480 V or 1500 V for 240 V.

2. Line to Ground: 1800 V for 480 V or 1200 V for 240 V.

2.3 ENCLOSURES

A. Indoor Enclosures: NEMA 250 Type 1.

B. Outdoor Enclosures: NEMA 250 Type 3R

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install SPD devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install SPD devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

1. Comply with manufacturer's written recommendation for conductor and circuit-breaker size for connecting SPD devices to distribution system. Match circuit-breaker size to conductor size. Coordinate with Drawings.
2. Provide multiple, 60-A circuit breaker as a dedicated disconnecting means for SPD unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
3. Complete startup checks according to manufacturer's written instructions.

C. SPD device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Do not energize or connect service entrance equipment to their sources until SPD devices are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the SPD installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to maintain SPD devices.

END OF SECTION

SECTION 26 51 19
LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of luminaire.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: one year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. CRI of minimum 65. CCT of 4100 K.

F. Rated lamp life of 50,000 hours.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. Nominal Operating Voltage: 120 V ac, 240 V ac, 277 V ac, 12 V dc, or 24 V dc.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

J. Housings:

1. Extruded-aluminum housing and heat sink.

2. Clear, anodized, powder-coat or painted finish.

2.3 CYLINDER

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

1. Albeo Technologies, Inc; A GE Company.
2. Cooper Lighting, an Eaton business.
3. GE Lighting Solutions.
4. Lightolier; a Philips group brand.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. OSRAM SYLVANIA.

B. Minimum 1000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. With integral mounting provisions.

2.4 DOWNLIGHT

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

1. Cooper Lighting, an Eaton business.
2. GE Lighting Solutions.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.
4. OSRAM SYLVANIA.

B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

2.5 LOWBAY

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

1. Albeo Technologies, Inc; A GE Company.
2. Cooper Lighting, an Eaton business.
3. GE Lighting Solutions.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. OSRAM SYLVANIA.

B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

2.6 RECESSED LINEAR

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

1. Albeo Technologies, Inc; A GE Company.
2. Cooper Lighting, an Eaton business.
3. GE Lighting Solutions.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. OSRAM SYLVANIA.

B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.7 STRIP LIGHT

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

1. Cooper Lighting, an Eaton business.
2. GE Lighting Solutions.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.
4. OSRAM SYLVANIA.

B. Minimum 750 lumens. Minimum allowable efficacy of 75 lumens per watt.

C. Integral junction box with conduit fittings.

2.8 SURFACE MOUNT, LINEAR

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

1. Albeo Technologies, Inc; A GE Company.
2. Cooper Lighting, an Eaton business.
3. GE Lighting Solutions.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. OSRAM SYLVANIA.

B. Minimum750 lumens. Minimum allowable efficacy of 75 lumens per watt.

C. Integral junction box with conduit fittings.

2.9 SUSPENDED, LINEAR

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

1. Cooper Lighting, an Eaton business.
2. GE Lighting Solutions.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.
4. OSRAM SYLVANIA.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.10 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers, and Globes:

1. Prismatic acrylic
2. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear anodized powder-coat painted finish.

2.11 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.12 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage .

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports: Sized and rated for luminaire weight.

E. Flush-Mounted Luminaire Support: Secured to outlet box.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch-diameter aircraft cable supports 120 inches in length.
2. Ceiling mount with pendant mount with 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 26 52 19
EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with integral or remote emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, coordinated with each other, using input from installers of the items involved:

B. Product Certificates: For each type of luminaire.

C. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

D. Sample Warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for recessed luminaires.

F. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast or driver.

1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.

b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
c. Humidity: More than 95 percent (condensing).
d. Altitude: Exceeding 3300 feet.

4. Test Push-Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: Sealed, maintenance-free, nickel-cadmium type.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

G. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.

1. Emergency Connection: Operate one fluorescent or LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast or driver.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Nightlight Connection: Operate lamp in a remote fixture continuously.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type.
6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the emergency power unit manufacturer, whichever is less.
7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Luminaires:

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

a. Amerlux.
b. Architectural Lighting Works.
c. Cooper Lighting, an Eaton business.
d. Lithonia Lighting; Acuity Brands Lighting, Inc.

2. Emergency Luminaires: as indicated on Interior Lighting Fixture Schedule, with the following additional features:

   a. Operating at nominal voltage of 120 V ac or 277 V ac.
   b. Internal emergency power unit.
   c. Rated for installation in damp locations, and for sealed and gasketed fixtures in wet locations.
   d. UL 94 5VA flame rating.

C. Emergency Lighting Unit:

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

   a. Amerlux.
   b. Architectural Lighting Works.
   c. Cooper Lighting, an Eaton business.
   d. Lithonia Lighting; Acuity Brands Lighting, Inc.

2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. Two LED lamp heads.
7. Internal emergency power unit.
8. External emergency power unit.

2.4 EXIT SIGNS

A. Internally Lighted Signs:

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

   a. Amerlux.
   b. Cooper Lighting, an Eaton business.
   c. Lithonia Lighting; Acuity Brands Lighting, Inc.

2. Operating at nominal voltage of 120 V ac or 277 V ac.
3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

2.5 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.

3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Clear, UV-stabilized acrylic.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. White anodized or powder coat finish.

E. Conduit: Rigid galvanized steel, minimum 3/4 inch in diameter.

2.6 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.7 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of fixture weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach fixtures directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of fixture oscillations. Support outlet box vertically to building structure using approved devices.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.

H. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 26 56 19
LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 1 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. CRI of minimum 65. CCT of 4100 K.

G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Nominal Operating Voltage: 120 V ac, 240 V ac or 277 V ac.

J. In-line Fusing: On the primary for each luminaire.

K. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

L. Source Limitations: Obtain luminaires from single source from a single manufacturer.

M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

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

   a. Architectural Area Lighting.
   b. Cooper Lighting, an Eaton business.
   c. H.E. Williams.
   d. Howard Lighting Products.
   e. Lithonia Lighting; Acuity Brands Lighting, Inc.

2. Luminaire Shape: As specified.
3. Mounting: Building.
4. Luminaire-Mounting Height: Minimum 8’ AFG, or as schedules.
5. Distribution: Type V typically – see schedule.

B. Canopy:

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

   a. Cooper Lighting, an Eaton business.
   b. H.E. Williams.
   c. Howard Lighting Products.
   d. Lithonia Lighting; Acuity Brands Lighting, Inc.

2. Shape: See schedule.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

   a. Color: Medium bronze unless otherwise scheduled.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth,

even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As selected from manufacturer's standard catalog of colors.
    b. Color: Match Architect's sample of manufacturer's standard color.
    c. Color: As selected by Architect from manufacturer's full range.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.2 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth.

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

   a. IES LM-5.
   b. IES LM-50.
   c. IES LM-52.
   d. IES LM-64.
   e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION

SECTION 27 05 00
COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the General Provision for furnishing materials and equipment, performing labor and services necessary for the installation of the communications systems shown on the drawings or as required to support the systems defined in these specifications.

B. Related Work Specified Elsewhere: Refer to all other Division 27 Specification Sections and Drawings, and to the specifications and drawings under the General Construction Contract to ascertain the extent of work included.

1.2 REFERENCE

A. EIA/TIA Electronics Institute of America/Telecommunications Institute of America

1. EIA/TIA - 568-B: Commercial Building Telecommunications Wiring Standard
2. EIA/TIA - 568-B: Addenda 1 minimum 4 pair UTP and 4 pair ScTP patch cable bend radius.
3. EIA/TIA - 568-B: Addenda 2 Grounding and bonding for screened balanced twisted pair horizontal cabling.
4. EIA/TIA - 568-B: Addenda 3 Supportable distances and channel attenuation for optical fiber applications by fiber type.
5. EIA/TIA - 568-B: Addenda 4 Additional media, recognition of category 6 and 850 nm laser optimized 50/125 µm fiber optic cabling.
6. EIA/TIA - 569-B: Commercial Building Standard for Telecommunications Pathways and Spaces
7. EIA/TIA - 604-2: Fiber Optic connector intermateability standard.
8. EIA/TIA - 606-A: Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
9. EIA/TIA-607: Commercial building grounding (earthing) and bonding requirements for telecommunications.
10. EIA/TIA 758-A: Customer owned outside plant telecommunications cabling standard.
11. EIA/TIA 758-A: Addendum 1 Outside plant fiber optic cabling practices.
12. EIA/TIA 7SB-67: Performance specifications for field testing of unshielded twisted pair cabling systems.

B. Federal Communications Commission

1. FCC: Part 15
2. FCC: Part 68
3. FCC: Part 76

C. Where applicable, all fixtures, equipment, and materials shall be as approved or listed by the following:

1. Factory Mutual Laboratories (FM).
2. Underwriters Laboratories, Inc. (UL).
3. National Electrical Manufacturers Association (NEMA).

D. All work shall conform to all federal, state, and local ordinances.

E. References to the National Electrical Code (NEC) and National Fire Protection Association (NFPA) are a minimum installation requirement standard. Special consideration should be given to Article 725, chapter

3 and chapter 8 of the NEC. Design contract drawings and specification sections shall govern in those instances where requirements are greater than those specified in the NEC and NFPA.

1.3 SUBMITTALS

A. Submit items in accordance with Division 1. The contractor is responsible for making submissions.

1. Submit to address indicated.
2. Identify each transmittal using applicable six digit specification section number.
3. Indicate description and manufacturer.
4. Provide information required for complete review of each item in one submittal.
5. Submittals for a specification section must contain all information applicable to that section. Partial submittals shall not be accepted.

B. Shop Drawings - General:

1. Shop drawings are required on all items of material and equipment to be used in the construction of the Project.
2. Prior to assembling or installing the work, prepare and submit shop drawings for approval in accordance with the general conditions and as hereinafter specified.
3. Definition - Shop drawing submittals are drawings, diagrams, schedules and other data specifically prepared for the work by Contractor, manufacturer, supplier, or distributor to illustrate some portion of the work. Shop drawings shall include complete installation drawings including system block and functional diagrams and terminal point to terminal point wiring diagrams with interfaces to related systems defined and referenced. System diagrams and wiring diagrams shall include all components of the system. Each component to be labeled on diagrams and cross referenced to technical data sheets and specifications.

    a. The contractor shall develop and submit complete submittals and do so in a timely manner. By failing to do so, the Contractor agrees to be fully responsible for any and all damages which might be occasioned by the contractor’s failure to do so.
    b. All shop drawings shall be created using the latest AutoCAD or AutoCAD compatible version. Incorporate all revisions upon completion of work. Submit with as-built drawings in both hard copy and electronic files.
    c. Scale drawings shall be prepared to show dimensional locations in plan and elevation of all equipment.
    d. Submit catalog information, factory assembly drawings, and field installation drawings as required for complete explanation and description of all items of equipment.

4. Preparation and submission of Shop Drawings shall consist of the following:

    a. Before preparing shop drawings: Consult all design drawings and specifications in detail, including those for the general construction contract. Obtain manufacturer's recommended and required installation instructions and have shop drawings prepared based on specific equipment and material intended for installation.
    b. Prior to submitting shop drawings to the Government, the Design Build Contractor shall have all shop drawing submittals reviewed, coordinated, commented on, and stamped by the Engineer of Record for Division 27/28. The Engineer of Record’s comments and stamp shall be attached and become part of the shop drawing submittal for review by the Government.
    c. After the Division 27/28. Engineer of Record has signed and stamped the Shop Drawings, a principal of the contracting firm shall sign all shop drawings (indicating conformance with plans and specifications) before submitting to Contracting Officer or releasing to workmen.

5. Review of shop drawings or schedules shall not relieve the Contractor from responsibility for

deviations from drawings or specifications, unless he has it in writing (and in letter form) called attention to such deviations at the time of submission and secured written approval; nor shall it relieve him from responsibility for errors in shop drawings or schedules.

6. Submittals (product data and system drawings) shall be in groups as follows:

   a. Group 1: General (includes):

      1) 27 05 00 - Common Work Results for Communications

   b. Group 2 : Communications Systems (includes):

      1) 27 13 23 - Communications Optical Fiber Backbone Cabling

7. Submittal Milestones. Unless indicated otherwise, the following submittal milestones shall apply to Division 27/28 systems.

   a. 100 days before Substantial Completion: Pre-System Drawing Submittal.
   b. 90 days before Substantial Completion: Product Data Submittal.
   c. 70 days before Substantial Completion: Final-System Drawing Submittal.
   d. 50 days before Substantial Completion: Test Plan Submittal.
   e. 30 days before Substantial Completion: Test Report Submittal.
   f. 20 days after Substantial Completion: Operation and Maintenance Manual.
   g. 30 days after Substantial Completion: As-Built Drawings.
   h. 30 days after Substantial Completion: Marked-Up A/E Design Drawings.

C. Shop Drawings -Specific:

1. Pre-System Drawings Submittal: Schedule a submittal review meeting for the purpose of Pre-System Drawings submittal review for this Division of work. Pre-System Drawings must contain all of the information that is required in the Final-System Drawing review for at least one equipment room, the main secured electronics room in the Administration Building, and the Control Room in the Administration Building. The Pre-System Drawing submittal shall be submitted as a submittal to the Contracting Officer. The Engineer of Record shall receive a single copy of the Pre-System Drawing submittal three weeks prior to the Pre-System Drawing review meeting. The Engineer of Record shall review the drawings and provide a detailed report to the Owner and Contractor on the drawings at the time of the review meeting. The review meeting location shall be determined by the Contract officer and shall be at either the A/E office, Site Office, or the Contractor's office. The purpose of the Pre-System Drawing review meeting is for the Owner, Engineer, and Contractor to agree to the proper level of documentation required for the Final-System Drawing before the Final-System Drawings are submitted to the Contracting Officer. If the Pre- System drawings are not sufficiently complete for proper review, an additional meeting shall be scheduled at the expense of the contractor.
2. Product Data Submittal: The Product data submittal shall include illustrations, standard schedules, performance charts, instructions, brochures, diagrams, test data, and other information furnished by the contractor to illustrate material, product or systems for some portion of the work. The submittal shall include adequate descriptive literature, catalog cuts, and other data necessary for the Contracting Officer to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts shall be legible and shall clearly identify equipment being submitted. Submittals shall be marked to show specification reference including the section and paragraph numbers. The submittals shall include information which confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, pictures, nameplate data and test reports as required. Additional specific requirements are listed in the individual sections. When substituting products other than the listed product, Contractor shall be responsible for coordinating with other Divisions for changes in dimensions, conduit sizes, and equipment space requirements.

a. Sample Submittal: When the Contractor is required to submit samples as defined in the part one of the specific specification section, the sample shall be submitted with the product data submittal so that the product literature and physical sample can be reviewed at the same time. The sample submittals are physical examples which illustrate materials, equipment or workmanship and establish standards by which the work shall be judged.
b. Installers Qualifications Submittal: Submit installer qualifications with the Product Data Submittal. Submit information required in the INSTALLER QUALIFICATIONS section.

3. Final-System Drawings Submittal: Final-System Drawings submittals are drawings and other data that convey how general equipment shall be applied specifically for this project. For each sub-system, the drawings shall include functional diagrams, riser diagrams, floor plans with conduit and wire scheduled, wiring diagrams for every field device with correct terminal or connector pin designations, large scale equipment room layouts in plan and elevation view, equipment cabinet layouts, wiring diagrams of all equipment cabinets with correct terminal or connector pin designations, I/O schedules, and head end details for integration of equipment such as touch screens, audio amplifiers, and video switchers. The drawings shall completely describe how each field device will be installed from the field device to the control center or other terminating location. The drawings shall be developed to the level that they can be used for maintenance trouble shooting. Include prepared text describing all or part of the integrated systems, functional diagrams of integrated system, elementary and interconnection wiring diagrams and wiring schedules for all communication and signal systems, control system and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams. Wiring diagrams must indicate proper shield connections and grounding and indicate floating shields where appropriate (field devices). System Drawings shall include ductbank cross sections showing the calculated conduit fill. Where innerduct is required, show and calculate the cross sections of the innerduct. Include in the System Drawings a description which shall include, and call attention to, all variances from the "For Construction Documents". Additional specific requirements are listed in the individual sections. System Drawings shall not be submitted until after the product submittals have been submitted.
4. Test Plan Submittal: The submittal shall outline a formal test plan and test procedure which demonstrates that each Division 27 system and the entire Division 27 System as a whole operates in accordance with the Division 27 Specification. The test plan shall include a written procedure for each type of device to be tested and a list including each device or function to be tested by the associated procedure and a single sign off blank for each device or function to indicate that the applicable test procedure has been successfully completed for the device or function. Where required, signal levels shall be recorded.
5. Test Report Submittal: The submittal shall be the completed test plan as described in Part 4 of the Section.
6. Operation and Maintenance Manual: Submit information required in the OPERATIONS AND MAINTENANCE MANUAL section.
7. As-Built Drawings: Submit information required in the RECORD DRAWINGS & AS BUILT DRAWINGS section.
8. Marked-Up A/E Design Drawings: Submit information required in the RECORD DRAWINGS & AS BUILT DRAWINGS section.

1.4 OPERATIONS AND MAINTENANCE MANUAL

A. Submit to the Contracting Officer six identical manuals that shall contain manufacturer's brochures of all items installed. The cover of the manual shall state the following information:

1. Project name
2. Location
3. Owner
4. Project Architect & Engineer (A/E)
5. Division 27 Engineer

6. Division 27 contractor (Name, Address, Phone Number)
7. General Contractor
8. Project Supervisors (General and Division 27)
9. Date of Project Completion

B. The Operations and Maintenance Manual shall be an updated version of the Product Data Submittal. In addition to the information that was originally submitted in the Product Data Submittal, the Operations and Maintenance Manual shall include the following information:

1. In the front of the Operations and Maintenance Manual provide:

a. A written guarantee as required in Part One of this Specification Section, "Guarantee".
b. The instructions for Maintenance Staff to place service calls for Critical and Sensitive maintenance issues. The instructions should include a first and last name, 24 hour telephone number, and mailing address.
c. A list of recommended inspection and/or test procedures, including frequency, to be performed by the facilities maintenance staff.
d. A list of the spare parts that will be turned over to the Government.
e. A description of the operation of the Control Panels and Touch screens.

2. At the front of each specification section in the Operations and Maintenance Manual:

a. List each product specified in the section and provide the name, address, and telephone number of the supplier. Next to each product approximate the normal delivery lead time.
b. Provide a description of the system or systems specified in the section.

3. Behind each piece of product data literature that was originally included in the Product Data Submittal:

a. Insert all installation and operational manuals that were shipped with the equipment from the manufacturer.
b. Insert copies of the warranties associated with the product. Ensure that warranties are included for the copper data systems specified in these specifications.

C. Along with the Operations and Maintenance Manual, furnish:

1. All software and applicable licensing required for all computers, PLC's, and other similar equipment installed on-site. Software shall be turned over in the original packaging on compact disk or similar. Software shall include but is not limited to all operating systems, databases, PLC programming software and source code, touchscreen programming software and source code, and telephone exchange programming software and source code.
2. One set of As-Built drawings black lines and one set of As-Built drawings in as a moisture proof storage tube in the main security electronics & communications equipment room.

1.5 RECORD DRAWINGS & AS BUILT DRAWINGS

A. Record Drawings shall be defined as updated <u>A/E Design</u> drawings that include all addenda, modifications, and field changes.

B. As-Built drawings shall be defined as updated <u>shop drawings</u> (system drawings and product data) that include corrections noted during the installation and system documentation generated during the installation which was not required to be resubmitted for review.

C. Maintain a complete set of all A/E Design drawings and shop drawings in the job site office.

1. Use these sets of drawings for showing as constructed installation of system equipment.
2. Where any material, equipment, wiring or system components are installed differently from that shown on the A/E Design drawings or submitted shop drawings, show such differences clearly and neatly using a red ink or indelible pencil.
3. At project completion, submit the marked up A/E Design drawings to the Contract Officer. Areas which have changed shall be clouded and marked with the number of the applicable amendment, RFI, or modification so that the documentation directing the change can be identified. These drawings shall be forwarded to the A/E and the A/E shall update the original A/E Design drawings with these changes which shall be the Record set of drawings.
4. At project completion, submit As-Built Drawings (corrected shop drawings on the original media) and submit the corrected black lines reproducible drawings to the Contractor Officer. Areas which have changed shall be clouded and marked with the number of the applicable amendment, RFI, or modification so that the documentation directing the change can be identified. Where the shop drawings were created on a computer aided drafting system, furnish electronic drawing files of shop drawings. This is not required to include manufacturer's proprietary information.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Contractor shall coordinate and install the work shown and described in the Division 27 drawings and specifications. The Division 27 Contractor shall be a company specializing in the design, fabrication, and installation of integrated security and communications control systems. The company shall comply with the requirements of DIVISION 27 INSTALLER QUALIFICATIONS described in this section. All work associated with Division 27 will be performed by a single contractor.

B. All equipment and materials required for installation under these specifications shall be installed new (less than one year from date of manufacture) and without blemish or defect.

C. All material and equipment shall be listed, labeled or certified by Underwriters' Laboratories, Inc. where such standards have been established. Equipment and material which are not covered by UL Standard will be accepted provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class that no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe will be considered if inspected or tested in accordance with national industrial standards such as NEMA, ICEA or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.

D. All custom equipment assemblies, including equipment cabinets, control consoles, and control panel stations, shall be UL listed 508A Standard for Industrial Control Panels.

1. All equipment and devices connected to Class 1 circuits shall be UL listed.
2. Equipment and devices connected to class 2 circuits on the load side of a class 2 power supply are not required to be UL Listed, unless specifically required by the Authority Having Jurisdiction.
3. Where Class 2 power supplies are not installed in a custom equipment assembly, the Class 2 power supplies must be clearly labeled as listed Class 2 supplies in accordance with NEC 725.

E. Each major component of equipment shall have the manufacturer's name, address, model number, and rating on as a plate securely affixed in as a conspicuous place. The nameplate of a distributing agent shall not be acceptable. NEMA Code Ratings, UL label, or other data that is die-stamped into the surface of the equipment shall be stamped in as a location easily visible. Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance. In many cases, equipment is oversized to allow for pickup loads that cannot be delineated under the minimum performance.

F. All equipment of one type shall be the product of one manufacturer.

G. All welders shall be certified by the Welding Bureau of the Mechanical Subcontractors Association of

America for the appropriate service, and shall perform all welding in accordance with the Welding Bureau's procedures and the ASA Code for welding.

H. All work shall meet or exceed the standards and procedures of the latest edition of the following:

1. National Fire Protection Association (NFPA):

   a. NFPA 70 — National Electrical Code (NEC).
   b. NFPA 101 — Life Safety Code.

2. AWS D1.1-90 — Structural Welding Code: Steel, 12th edition.
3. Occupational Safety and Health Act (OSHA)

1.7 PROTECTION OF SYSTEMS AND EQUIPMENT

A. Protect all materials and equipment from damage during storage at the site and throughout the construction period. Equipment and materials shall be protected during shipment and storage against physical damage, dirt, moisture, cold, and rain.

B. Damage from rain, dirt, sun, and groundwater shall be prevented by storing the equipment on elevated supports and covering them on all sides with securely fastened protective rigid or flexible waterproof coverings.

C. Piping shall be protected by storing it on elevated supports and capping the ends with suitable closure material to prevent dirt accumulation in the piping.

D. During construction, cap the top of all conduits and raceways installed vertically.

E. During installation, equipment shall be protected against entry of foreign matter on the inside, and be vacuum cleaned both inside and outside before testing, or operating.

F. Damaged equipment shall be, as determined by Contracting Officer, placed in perfect operating condition or be returned to the source of supply for replacement. Refurbished equipment shall not be acceptable.

G. Painted surfaces shall be protected with removable heavy Kraft paper, sheet vinyl, or equal, installed at the factory and removed prior to final inspection.

H. Damaged paint on equipment and materials shall be repainted with painting equipment and finished with same quality of paint and workmanship as used by manufacturer so repaired areas are not obvious.

I. Division 27/28 equipment shall not be installed until all the other disciplines are finished with their work in the Control Center, Main Secured Equipment room and Remote Secured Equipment rooms and the equipment rooms are thoroughly cleaned.

1.8 INTERPRETATION OF CONTRACT DOCUMENTS

A. This section of the specifications and related drawings describe general provisions applicable to every section of Division 27.

B. Attention is directed to Division 1, General Conditions, which are binding in their entirety on this portion of the work, particularly the paragraphs concerning materials, workmanship, substitutions, and project coordination and scheduling.

C. When articles, materials, operation, or methods related to execution of the work are noted, specified, drawn, or described, require execution of each such item of work and provision of all labor, materials, equipment, and appurtenances required for execution.

D. Particular attention is directed to the drawings and other contract documents for information pertaining to required items of work which are related to and usually associated with the work of this Division of the specifications, but which are to be provided as part of the work of other Divisions of the specifications, under the General Construction Contract.

E. No exclusions from, or limitations in, the language used in the drawings or specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are to be omitted.

F. The drawings of necessity use symbols and schematic diagrams to indicate various items of work. Of these neither has any dimension significance, nor do they delineate every item required for the intended installations. The work shall be installed in accordance with the intent diagrammatically expressed on the drawings and in conformity with the dimensions indicated on final architectural and structural working drawings and on equipment shop drawings. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded. When abbreviations appear on the drawings or specifications in lower-case letters with or without periods, their meanings shall be the same as stated above.

G. Certain details appear on the drawings which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the indicated work.

H. Information as to the general construction shall be derived from structural and architectural drawings and specifications only.

I. The use of words in the singular shall not be considered as limited where other indications denote that more than one item is indicated.

J. The drawings are diagrammatic and indicate the general arrangement of systems and equipment unless indicated otherwise by dimensions or detail drawings of 1:20 scale or larger. For exact locations of building elements, refer to dimensioned drawings; however, field measurements take precedence over dimensioned drawings. Report any discrepancies discovered between communications, systems drawings and the drawings for other divisions of work under the general construction contract.

K. Conduit and raceway shown on the drawings are diagrammatic only.

1.9 DESCRIPTION OF SYSTEMS

A. Furnish and install all materials for the systems so as to provide a functioning system in compliance with performance requirements specified. The omission of express reference to any parts necessary for, or reasonably incidental to, a complete installation shall not be construed as a release from furnishing such parts.

B. The wiring specified and shown on the drawings is for complete and workable systems. Any deviations from the wiring shown due to a particular manufacturer's requirements shall be made at no additional cost to the Government. Changes in electrical service to equipment due to substitutions of equipment by the Contractor shall be at the cost of the Contractor.

1.10 DELINEATION OF WORK:

A. Coordinate the Work of this Section with that of other Sections as required to ensure that the entire work of this Project shall be carried out in an orderly, complete and coordinated fashion. Check proposed equipment against space available as indicated on drawings, and make sure that proposed equipment can be accommodated. If interferences occur, direct concerns in writing to the Contract Officer for resolution; or, the Contractor shall, at his own expense, provide proper materials, equipment, and labor to correct any damage due to defects in his work caused by such interferences.

B. A Division 27 representative shall attend all weekly on site construction meetings. The Contract Officer may waive this requirement for any weekly on site construction meeting.

C. Division 27 is required to supply all necessary supervision and coordination of information to any contractor who is performing work to accommodate Division 27 installations. Where Division 27 is required to install items which they do not purchase, they shall include for such items:

1. The coordination of their delivery.
2. Their unloading from delivery trucks driven into any designated point on the project property line at grade level.
3. Their safe handling and field storage up to the time of permanent placement in the project.
4. The correction of any damage, defacement or corrosion to which they may have been subjected while under the possession of the Subcontractor.
5. Their field assembly and internal connection as may be necessary for their proper operation.
6. Their mounting in place including the purchase and installation of all dunnage, supporting members, and fastening necessary to adapt them to architectural and structural conditions.
7. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

D. The specifications for the overall construction of the project, under the general construction contract, delineate various items of work under separate section headings. The list below sets forth this delineation to the extent that it affects the Division 27 work category. In the absence of more detailed information, this list shall be taken as a specific instruction to Division 27 to include the work assigned to them. Indications that each subcontractor is to perform an item of work means that he is to perform the work for his own accommodation only, unless specifically noted otherwise.

1. General Contractor shall be responsible for coordination of all conduit, equipment, wiring, installation, and testing of systems defined in Division 27.
2. Unless specifically noted otherwise, all conduit systems as shown on the Division 27 drawings or specified herein shall be furnished and installed by Division 26, in accordance with the Division 26 specifications. Division 27 shall be responsible for ensuring that adequate conduit facilities are installed to support the intended functions of Division 27. Primary conduit systems are shown on the drawings; however, Division 27 shall be responsible for additional conduits as required or increase in size of conduits to effect installation of the systems defined in Division 27. Division 27 shall verify the adequacy of the conduit systems and review the conduit system requirements with Division 26 prior to installation.
3. Cables for the Division 27 equipment shall be pulled through the conduit system by Division 26. Division 27 shall be responsible for providing all the cables required to support the Division 27 systems, and for coordinating and supervising the cable installation by Division 26. Division 27 shall be responsible for ensuring the integrity of the cables before and after installation.
4. Coordinate with Division 23, Division 26 and other Divisions of work for all required connections between fire alarm systems and systems furnished under other Divisions of work.
5. Coordinate with Division 26 to provide Uninterruptible power system (UPS) power to all communications systems.
6. Division 26 shall be responsible for furnishing and installing the power grounding system for all communications systems equipment.
7. Division 26 shall be responsible for 120VAC power circuits and connections where shown on the electrical contract drawings and where specifically shown on the security electronics, communications, and fire alarm systems contract drawings as Division 26 responsibility. Unless specifically excluded, any 120VAC connections required to complete the Division 27 systems

shall be the responsibility of Division 26.

8. Division 27 shall furnish and install surge arrestors and terminate the surge arrestor grounds to the power ground system for communications systems equipment.
9. Division 27 shall verify and furnish electrical power requirements to Division 26 in a timely manner so as not to impede the progress of the work.
10. Division 27 shall be responsible for any additional power required (not shown on contract drawings) to effect the installation of the systems contained herein.
11. Raceway systems shall be provided as specified in, and conformance with, applicable sections of Division 26 including:

    a. Section 26 05 33 Raceway and Boxes for Electrical Systems

1.11 GUARANTEE

A. Work shall be guaranteed to be free from defects. Defective materials and workmanship, as well as damage to the work of other trades resulting from same, shall be replaced or repaired as directed by the Contracting Officer for the duration of the stipulated guarantee periods.

B. Furnish to the Contracting Office a written guarantee that the installation, including controls and all other equipment covered under this section of the specifications, performs in as a quiet, efficient, and a satisfactory manner with no more than normal service.

C. The primary supplier of communications systems hardware and software shall guarantee in writing, through the contractor, all phases of his system (including, but not limited to, software, hardware, and peripheral equipment) for as a period of two years from date of written final acceptance against defective materials, design, and workmanship. Upon receipt of notice from the Contracting Officer of failure of any part of the guaranteed system, the contractor, with the assistance of the supplier, shall promptly restore the defective component to provide an acceptable system at no cost to the Government.

D. The guarantee period shall commence upon acceptance by the Government. Acceptance tests and procedures shall be developed by the contractor and accepted by the Contracting Officer.

E. Acceptance by a manufacturer of an order for equipment for this contract signifies acceptance of this guarantee.

F. During the guarantee period, there shall be no charges to the Government for service calls (mileage, labor, travel, expenses, etc.) for guarantee work.

1.12 DIVISION 27 INSTALLER QUALIFICATIONS:

A. General Requirements:

1. The Division 27 Installer shall have total responsibility for the coordination and installation of the work shown and described in the Division 27 drawings and specifications. The Division 27 Installer shall be a company specializing in the design, fabrication, and installation of integrated communications control systems. The company shall have a minimum of five years of experience in this specialized field and shall have completed a minimum of five projects similar in scope to this project.
2. It is the responsibility of the General Contractor and the Division 27 installer to ensure that licensing requirements are meet. The Division 27 installer must provide evidence of a performance bond to the General Contractor.

B. Contractor Qualifications:

1. The principle members and key personnel to be assigned to the project shall each have a minimum

of five (5) years experience in completing projects of equal scope, quality, type, and complexity to that required herein.

2. The company shall have a minimum 5 years of experience in the field of communications systems.
3. The company shall have completed a minimum of 5 projects similar in scope to this project. The Division 27 contract value of the project shall be similar to the Division 27 contract value for this project.
4. The company shall have in its employ and staff the project with installation technicians certified as either BICSI level III installers or NECA/IBEW JATC Installer-technicians

C. Technical Qualification Requirements:

1. The Division 27 Installer shall submit to the Government the following information. Part 1 of the technical qualifications shall include the following:

   a. A history of the company that reflects the length of time the Division 27 Installer has performed services similar to those required for this project.
   b. Name, address, and telephone number of the organization's current bonding company.
   c. Evidence that the principle members and key personnel of the organization have experience in successfully completing projects of equal scope, quality, type and complexity to that required herein. Include resume(s) of personnel in the employ of the organization that have experience in the design, fabrication, and installation of comparable systems. Include a delineation of each individual's responsibilities on this project. Resumes must include information about the individual's detention experience, system integration capabilities and level of education completed.
   d. List of at least 5 comparable, completed projects on which work has been performed that are operational and accepted by the owner. Include for each facility the following:

      1) Name and location of project.
      2) Date of occupancy.
      3) Name, address, and telephone number of Government's agent (or for other than a federal facility, an individual employed by the operating agency familiar with the facility's communications systems).
      4) Name, address, and telephone number of Contracting Officer (or construction manager for a non-federal project).
      5) Name, address, and telephone number of General Contractor.
      6) Name, address, and telephone number of Engineer of Record.
      7) A description of the systems involved, the completion dates, and the contract amount for the equipment and services for which the Contractor had responsibility.
      8) The contract amount for work performed.

   e. List of all projects, within the last 5 years, in which the organization has been involved in litigation with a city, county, state, or Federal Government agency. Include summary of final decisions and status of pending litigation.

2. The technical qualifications shall also indicate an understanding of the scope, quality, and technical aspects of the Division 27 work. Part 2 of the technical qualifications shall include the following:

   a. A technical description of the Division 27 Installer's approach to implementing each of the major systems included in Division 27. Interfaces with other Installers' work, if any, must be specifically addressed.
   b. For each major system in Division 27, a delineation of the tasks to be performed by the Division 27 Installer's staff and those tasks, if any, to be performed by third party or sub-contract Installers. Technical proposals for each Installer must be included with the Division 27 Installer's proposal.

c. A description of the overall system integration, which shall include a functional block diagram of the integrated system. For each functional unit shown on the diagram, the Division 27 Installer shall provide a description of the functional capabilities and characteristics of the unit, including the hardware and software systems associated with the functional unit.

d. A functional description of the software to be furnished. Software that is currently available and software that is to be developed by the Installer shall be identified.

1.13 COOPERATION WITH OTHER TRADES:

A. Coordinate the Work of this Section with that of other Sections as required to ensure that the entire work of this Project will be carried out in an orderly, complete and coordinated fashion.

B. Check equipment against space available as indicated on the Drawings, and make sure that the proposed equipment can be accommodated. If interferences occur, bring them to the attention of Architect/Engineer, in writing. Otherwise, the contractor shall, at his own expense, provide proper materials, equipment, and labor to correct

PART 2 - PRODUCTS

2.1 GENERAL:

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are available.

B. When more than one unit of the same class of equipment or material is required, such units shall be the products of a single manufacturer.

C. All products shall be new and unused and without blemish or defect.

2.2 EQUIPMENT ASSEMBLIES AND COMPONENTS:

A. All components of an assembled unit need not be products of the same manufacturer; however, all components must be acceptable to the Contracting Officer.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for the final assembled unit.

C. Components shall be compatible with one another and with the total assembly for the intended service.

D. Constituent parts that are similar shall be the product of as a single manufacturer.

E. Moving parts of any element of equipment of the unit normally requiring lubrication shall have means provided for such lubrication, and shall be adequately lubricated at the factory prior to delivery.

F. All factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

2.3 EQUIPMENT IDENTIFICATION:

A. In addition to the requirements of the NEC, install an identification sign that shall clearly indicate information required for use and maintenance of items such as equipment cabinets, telephone boards, data equipment racks, fiber optic cable termination enclosures, and other significant equipment. Identification shall be provided for each device defined above.

B. Nameplates shall be a laminated black phenolic resin with a white core and engraved lettering a minimum of 8 mm high. Nameplates that are furnished by manufacturer, as a standard catalog item, or where other methods of identification are herein specified are exceptions.

2.4 ACCESS TO EQUIPMENT:

A. All equipment shall be installed in location and manner that shall allow for workable access for maintenance and inspection.

B. Access to electrical equipment shall comply with the National Electric Code.

C. Clearance of at least 930 mm shall be maintained in front of all Division 27 cabinet openings (front and rear), data equipment racks, and telephone boards. Notify the Contract Officer prior to equipment installation where space or equipment interferences do not permit the required clearances.

D. Where concealed by inaccessible finishes, provide access doors to raceway junction boxes, devices, and all other items requiring periodic maintenance, operation, or adjustment. Access doors are to be sized and located for ease of performance of the function intended. Coordinate location of access doors with all trades affected. Access doors for walls, ceilings, and floors, both standard and fire rated, are specified in Division 8. Security access doors are specified in Division 11. Provide ceiling access panels for any junction boxes or device, installed above inaccessible ceilings.

2.5 SECURITY FASTENERS:

A. Security Fasteners for Division 27 equipment shall be torx head with peg. Fasteners for exterior devices shall be stainless steel. Break off head style fasteners shall <u>not</u> be used for any Division 27 equipment.

B. Devices located in areas accessible to inmates shall be installed with security fasteners as specified herein.

C. Security Fasteners for Division 27 equipment shall be torqued to the fastener manufacturer's recommended minimum torque value.

2.6 MAINTENANCE MATERIALS

A. Special tools for proper operation and maintenance of the equipment provided under this specification shall be delivered to the Project Director and as a receipt requested for same.

B. Where specified, provide the Contracting Officer with spare parts, equipment, and materials, and request as a receipt for same.

2.7 SPARE PARTS

A. Contractor shall maintain a spare parts inventory.

B. During the maintenance and service period, Contractor shall maintain a log of all component failures and parts replaced. This log shall be submitted to the Facility Manager on a quarterly basis.

C. Six months prior to the expiration of the maintenance and service period, the Government shall use the replace parts log to evaluate the onsite spare parts inventory required for future maintenance by the Government.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

A. Prior to any work where it affects the installation of his equipment, the contractor shall carefully inspect the installed work of all other trades and verify that all such work is complete to the point where his installation may properly commence.

B. Verify that all equipment may be installed in accordance with all pertinent codes and regulations, the original design, and the referenced standards.

C. In the event of discrepancy, immediately notify the Contracting Officer.

D. Do not proceed with installation in areas of discrepancy until such discrepancies have been fully resolved.

3.2 INSTALLATION

A. Install all equipment in strict accordance with the manufacturer's recommendations and reviewed shop drawings.

B. Secure equipment using fasteners suitable for the use, materials, and loads encountered. If requested, submit evidence proving suitability. Do not attach electrical materials to roof decking, removable or knockout panels, or temporary walls and partitions unless indicated otherwise.

C. The wiring specified and shown on the drawings is for complete and workable systems. Any deviations from the wiring shown due to a particular manufacturer's requirements shall be made at no additional cost to the Government. Changes in electrical service to equipment due to substitutions of equipment by the Contractor shall be at the cost of the contractor.

D. Where the Contracting Officer determines that the contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled as directed at no additional cost to the Government. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing over or crawling under obstacles such as motors, pumps, belt guards, transformers, piping, and ductwork.

E. Equipment Location: As close as practicable to locations shown on drawings.

F. All devices mounted in the floors, walls or in a dropped ceiling should be flush mounted unless noted otherwise.

G. Working spaces shall be not less than specified in the NEC for all voltages specified.

3.3 WORK PERFORMANCE

A. Coordinate location of equipment and conduit with other trades to minimize interferences.

B. Holes through concrete and masonry in new and existing structures shall be cut with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand, or manual hammer-type drills shall not be allowed except where permitted by the Contracting Officer as required by limited working space.

C. Holes shall be located so as not to affect structural sections such as ribs or beams.

D. Holes shall be laid out in advance. Contracting Officer shall be advised prior to drilling through structural sections for determination of proper layout.

E. Structural Penetrations:

1. Where conduits, wireways, and other raceways pass through fire partitions, fire walls, or walls and floors, install a fire stop that provides an effective barrier against the spread of fire, smoke, and gases. Fire stop material shall be packed tightly and completely fill clearances between raceways and openings.
2. Fire-stop material shall conform to the requirements of applicable code sections for firestopping.
3. Floor, exterior wall, and roof seals shall be watertight. Walls and floors that are cored for installation of conduit shall be sleeved with steel tubing, grouted, and the space between the conduit and sleeve filled as specified herein.
4. Tubing shall extend 25 mm minimum above finished floor unless noted otherwise.

F. Hangers and other supports shall support only equipment and materials. Provide not less than as a safety factor of five, which shall conform to any specific requirements as shown on the drawings or in the specifications.

G. In areas inside the security boundary, exposed equipment and materials, including screws and other fasteners, shall be tamper proof. Cover plates shall have rounded edges to eliminate sharp corners.

3.4 CABLE TERMINATIONS AND DRESS

A. Installation of communications conductors shall adhere to the following:

1. Cables shall be dressed and secured using hook-and-loop type straps in cabinets and at control panels and consoles to present a neat and orderly installation. At the discretion of the contractor, cable duct may be installed in equipment cabinets, backboards and control consoles to facilitate satisfying this requirement.
2. Cables shall be secured to equipment cabinet backboards, console members, or to other system components using cable clamps and wraps. Contractor shall furnish and install cable support posts if required to facilitate system installation.
3. Cables and conductors shall be terminated with approved cable termination connectors compatible with the specific termination.

3.5 SURGE AND LIGHTNING PROTECTION

A. Electrical circuits supplying power to system components shall be equipped with surge protectors.

B. All Division 27 metallic cables and conductors entering the facility from a point exterior to the building shall be equipped with surge protection.

3.6 EXCAVATING, TRENCHING, BACKFILLING AND RESURFACING:

A. Do not excavate below required depth except as necessary for removal of unstable soil or when rock is encountered. When rock is encountered, excavate 150 mm below the required depth.

B. Where backfill compaction is critical (e.g. under floor slabs, roadways, sidewalks, trenches deeper than 1200 mm), test the degree of compaction each 23000 linear mm of trench and each 600 mm of depth. Test as required by Specifications for "Sitework" and compact backfill until density is acceptable.

C. Repair the excavated area to original pre-excavation condition. Repair and replace sidewalks, roadways, etc.

3.7 TEST PROCEDURES

A. Testing - General

1. The Contracting Officer shall reserve the right to tabulate the results of any demonstration or acceptance tests. If the failure rate exceeds 10% for any one system the Contracting Officer shall have the option of halting the test or demonstration and rescheduling the test or demonstration. If the test or demonstration is rescheduled the Contractor shall be responsible for all additional expenses occurred including travel and lodging for all of the Contracting Officer's designated representatives.
2. Verify that all requirements of this specification are fulfilled. Verification shall occur through a combination of analyses, inspections, demonstrations and tests, as described below. Include the test and demonstration requirements in this article in the project milestone schedule. The Contracting Officer shall be allowed to witness any demonstrations and tests.
3. Verification by Inspection: Verification by inspection includes examination of an item and the comparison of pertinent characteristics against the qualitative or quantitative standard set forth in the cited paragraph. Inspection may require moving or partially disassembling the item to accomplish the verification. Inspection shall be made of all equipment installations, proper functioning of all locking hardware and lock controls, mounting and wiring of electrical and signal distribution cabinets and components, and mounting and placement of devices. The Contacting Officer shall have full opportunity to witness the required inspections or to conduct his own inspections of the installation.
4. Each assembled component of a system specified in Division 27 shall be tested to verify its proper functioning.
5. The Engineer of Record shall attend and develop a report for all of the testing milestones listed below. The Engineer of Record’s Report shall be submitted to the Government for their review.
6. Testing Milestones. Unless indicated otherwise, the following testing milestones shall apply to Division 27 systems.

   a. 100 days before Substantial Completion: Factory Test.
   b. 50 days before Substantial Completion: Preliminary Site Test.
   c. 40 days before Substantial Completion: Systems Test.
   d. 35 days before Substantial Completion: Final Acceptance Test.

B. Testing - Specific

1. Factory Tests: Following factory engineering and assembly of the complete Division 27 System, demonstrate the operation of the system to the Contracting Officer and his or her designated representatives. The demonstrations shall consist of the following:

   a. All equipment cabinets and control stations shall be completely assembled and ready for shipment to the job site. All of the cabinets and control stations shall be in the factory ready for inspection. All of the cabinets and control stations shall be networked together via temporary fiber optic and copper jumper cables as required to effect a working system.
   b. Any deficiency pertaining to specification requirements shall be corrected prior to shipment of the equipment to the project site.*

2. Preliminary Site Tests: Following delivery of the System from the factory and after the system has been installed, demonstrate the operation of the system to the Contracting Officer and his or her designated representatives. The Preliminary Site Tests procedures described in section 27 05 00 shall be the same as the Factory Test procedures except the temporary jumper cables and temporary field devices shall be replaced by the completed communications backbone and permanently installed equipment.

   a. All deficiency, if any, that were uncovered at the Factory Test shall be demonstrated as operating correctly at the Preliminary Site Test.

b. Any deficiency pertaining to specification requirements shall be corrected prior to the Systems Operation Test.

3. Systems Test: When the Division 27 systems are fully functional, conduct a formal test to be known as the “Systems Test,” in which all components and systems of Division 27 are demonstrated to operate together as one system in accordance with the submitted "Test Plan" described in part one of this section. This test shall be conducted by the Contractor but may be witnessed by the Contracting Officer.

   a. The Contractor shall test every component of the system using the check list and procedures developed for the "Test Plan" described in part one of this section.
   b. After the "Test Plan" has been filled out and singed off by the Contractor, the "Test Plan" shall be known as the "Test Report".
   c. If the "Test Report" identifies some "punch list" type deficiencies in the Division 27 System, the Contractor shall provide a narrative of the deficiency with the corrective action for a resolution. The Contracting Officer shall have the right to determine if the deficiencies listed are "punch list" type deficiencies or incomplete work by the Contractor.
   d. The "Test Report" shall be submitted to the Contracting Officer.

4. Final Acceptance Tests: The Contracting Officer shall be in receipt of the "Test Report" compiled from the Systems Test for fourteen days before the Final Acceptance Test begins. The Contracting Office will use the fourteen day period to evaluate the test report for completeness. The Engineer of Record shall also use the fourteen day period to evaluate the test report and shall provide the Contracting Officer a detail review of the test report before the end of the fourteen day period. If the test report is determined to be incomplete, the Contractor must make all corrections and resubmit the report allowing the Contracting Officer another fourteen day review period to determine completeness.

   a. The Contracting Officer shall be notified in writing fourteen days in advance of the proposed Final Acceptance Test.
   b. The Division 27 system shall be subjected to complete functional and operational tests called the “Final Acceptance Tests” by the Government and Government's representatives.
   c. Carefully plan and coordinate the Final Acceptance Tests so that all tests can be satisfactorily completed with 2 weeks of testing. Provide all necessary instruments, labor, and materials require for tests, the equipment manufacturer's technical representative, and qualified technician in sufficient numbers to perform the tests within the time limits imposed by this specification. Also make available four two-way portable radios for communications during testing. The tests shall be structured so that all sensors and controls are stimulated directly in their installed and finally adjusted positions and all audible and visual displays, signals, alarms and other responses are observed and printed. At the time of final acceptance testing, all required tests shall be repeated and all defects shall be corrected until the system is found to be acceptable to the Contracting Officer.
   d. Fourteen (14) days prior to the Scheduled Substantial Completion date a log of all Final Acceptance Test activities and results shall be maintained. Typed copies of this log shall be submitted to the Contracting Officer. All Division 27 systems shall be complete and operational including correction of all punch list items.
   e. After final adjustments and Final Acceptance Tests have been completed, provide a competent manufacturer's technical representative to instruct the Contracting Officer on the operation and maintenance of equipment installed. Supply qualified personnel to operate equipment for a period of thirty (30) days to ensure the Contracting Officer is qualified to take over operation and maintenance of the Division 27 Systems. Instruction periods shall be as designated by the Contracting Officer and shall not necessarily be consecutive. The manufacturer's technical representative shall conduct onsite training on specialized electronic systems.

3.8 CLEANUP

A. Bright metal or plated work shall be thoroughly polished. Pasted labels, dirt, and stains shall be removed from the devices.

B. Daily during construction and prior to Government acceptance of the building, remove from the premises and dispose of all packing material and debris caused by work performed under Division 27.

C. Remove all dust and debris from the interior and exterior of the equipment cabinets.

3.9 TRAINING

A. Division 27 shall be responsible for the training of the facility’s personnel.

B. Division 27 shall include costs for the training of two Government Technicians at the equipment manufacturer’s facility. The Government shall be responsible for only travel and living costs.

1. Manufacturer’s training shall be provided for the following systems:

a. Fiber Optic System (Terminations and Care)

2. Manufacturer training shall include instruction, software, and materials consisting of operation and maintenance documents. Instruction shall include: installation, maintenance, add, moves or changes, without compromising any codes, regulations, or licensing. The manufacturer shall provide a copy of all systems related software to the Government during the training. The persons conducting the training shall be factory trained and manufacturer certified on the systems. At the completion of the training, the technicians shall be factory/manufacturer certified in the systems and as a “self maintainer” of the systems.

C. Division 27 shall include costs for the training of twenty Government Operations Personnel at the institution.

1. Operation training shall be provided for the following systems:

a. Generator Controls and Monitoring System

2. The persons conducting the training shall be factory trained and manufacturer certified on the systems. All training materials shall be provided. Thirty two hours of classroom and field training shall be provided within a consecutive five day period.

D. Division 27 shall include costs for the training of ten Government Maintenance Personnel at the institution.

1. Maintenance training shall be provided for each of the Division 27 Systems.
2. The persons conducting the training shall be at factory trained and manufacturer certified on the systems. All training materials shall be provided. Forty hours of classroom and field training shall be provided within a consecutive five day period.

E. Division 27 shall coordinate with the Government for scheduling of training. The training programs shall be conducted in accordance with the schedule as established by the Contracting Officer. The training programs shall not be conducted concurrently so as to allow specific individuals to attend all programs. Operations training shall come after manufacturer’s training.

F. All training sessions shall be recorded using a DVD video format by a professional independent company with experience in recording at least 12 events in the last 12 months. Three copies of each disk shall be provided to the Contracting Officer upon completion of the training program.

3.10 MAINTENANCE AND SERVICE

A. Maintenance and service shall be provided as part of this contract by the primary supplier through the contractor during the one year guarantee period. This service shall consist of supplier's factory-trained representative providing the following:

1. Personnel factory-trained by the manufacturers of the system's components.
2. Authorized representative of the manufacturer and have an agreement of factory support.
3. Inventory of spare parts to support the systems,
4. Five years of experience (minimum) servicing systems of the type included in this project.
5. Capability of making additions or changes to the software systems used in this project.
6. Capability of servicing the individual system components and the total integrated system.
7. All test equipment.

3.11 TURNOVER OF MOVEABLE EQUIPMENT:

A. Provide an inventory list of all spare parts, test equipment, and moveable equipment such as touch-screen monitors, local origination equipment, with a notification of receipt by the Government signed by the Contract Officer for each piece of equipment.

END OF SECTION

SECTION 27 13 23
COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the facility wide fiber optic distribution system as shown on the drawings or as required to support the systems defined in these specifications. The work under this section consists of furnishing materials and equipment, performing labor and services necessary for the installation of the facility wide fiber optic distribution system required for the security electronics, communications, and fire alarm system.

B. Related Work Specified Elsewhere: Refer to all other Division 27 specification sections and drawings, and to the specifications and drawings under the General Construction Contract to ascertain the extent of work included.

1.2 SUBMITTALS

A. Since the Division 27 systems must be reviewed by the Contracting Officer as a system, no individual, specific submittal shall be made for this section. Submittals shall be packaged in groups and shall be made in accordance with the Common Work Results (Section 27 05 00) of these specifications.

B. When making the submittal as required by Section 27 05 00, include this additional information.

1. Submit Quality Assurance data sheets prepared by the cable supplier for each cable reel.
2. Submit final test results for tests conducted on each installed fiber. Data shall include power through loss meter test results.
3. Test results shall be bound in a single binder titled "Fiber Optic Cable Distribution Performance Measurements". In addition to the data sheets for each fiber test, the data shall be organized in tables with the fiber identifier on the left hand column and columns for average loss, measured link length, and link loss.

1.3 SYSTEM DESCRIPTION

A. GENERAL

1. A facility wide fiber optic cable system shall be furnished and installed to support the following systems or functions:

   a. Closed circuit television video and control data to remote generator status and provide touch screen contol of new generators.

2. Cables shall be installed in the site duct bank system and routed in accordance with the fiber optic site distribution riser diagram shown in the drawings.
3. Cables shall be installed point-to-point from the Secure Electronics room in the Low Security facility Utility Plant to the Secure Electronics room in the Medium Security facility Utility Plant.
4. All terminations and extention/cabling to Plant Management offices will be by Generator Manufacturer’s control contractor.

B. All cable shall be continuous between the terminals with no splicing.

C. All fiber strands shall be terminated with "ST" type connectors. Interface to fiber optic transceivers and other fiber optic equipment shall be made at the bulkhead connectors utilizing patch cables.

PART 2 - PRODUCTS

2.1 FIBER CABLE

A. All fiber optic cable shall be tight buffered optical cable with a color coded UV cured acrylate buffer primary coating. The secondary buffer coating shall consist of tight buffer high performance PVC. Each optical cable shall contain rod fillers and synthetic yarn for strength and rigidity. The rod fillers shall consist of a central dielectric strength member surrounded by an extruded elastic polymer coating. The synthetic yarn shall be individually tensioned and held helically over the cable core.

1. All of the fiber optic cable shall conform to the following specifications as a minimum:

   a. Primary Coating: 250 +/- 15 microns
   b. Secondary Coating: 900 microns
   c. Minimum Bend Radius

      1) During Installation: 20 X Cable O.D.
      2) Long Term: 10 X Cable O.D.

   d. Operating Temperature: -40ºC to +85ºC
   e. Storage Temperature: -55ºC to +85ºC
   f. Crush Resistance: 1,800 N/cm
   g. Proof Test: 100 kpsi (Minimum)
   h. Tensile Strength: (Minimum)

      1) Fiber Count / During Installation / Long Term

	Fiber Count	During Installation	Long Term
a)	6 fiber or less	1600 N	500 N
b)	8 fiber	1800 N	525 N
c)	10 to 12 fiber	2100 N	700 N
d)	14 to 18 fiber	2700 N	1000 N
e)	20 to 24 fiber	3000 N	1000 N
f)	24 and greater	3000 N	1000 N

2. All of the multi-mode fiber strands shall conform to the following specifications as a minimum:

   a. Fiber Type: Multimode, Graded Index
   b. Core Diameter: 62.5 microns
   c. Cladding Diameter: 125 microns
   d. Maximum Attenuation

      1) @ 850 nm: 3.0 dB/km
      2) @ 1300 nm: 1.0 dB/km

   e. Minimum Bandwidth

      1) @ 850 nm: 300 MHz-km
      2) @ 1300 nm: 800 MHz-km

3. All of the single mode fiber strands shall conform to the following specifications as a minimum:

   a. Fiber Type: Single-Mode
   b. Core Diameter: 9 microns
   c. Cladding Diameter: 125 microns

d. Maximum Attenuation

1) @ 1310 nm: 0.4 dB/km
2) @ 1550 nm: 0.3 dB/km

B. OUTDOOR CABLES

1. The outer jacket shall consist of PVC having a wall thickness of 1 mm and a minimum wall thickness of 0.75 mm at any point.
2. The cables outside diameter shall be

a. 48 fibers or less less than 10.5mm

3. Cable shall be Optical Cable DX series or approved equal.

C. HORIZONTAL DISTRIBUTION AND BREAKOUT CABLES

1. The outer jacket shall consist of flame-retardant PVC (OFNR rated) having a wall thickness of 1 mm and a minimum wall thickness of 0.75 mm at any point.
2. The cables outer jacket and cable core shall be designed for installation survivability.
3. The cables shall be suitable for indoor and outdoor use.
4. The cables fiber strands shall be designed for direct termination with standard connectors.
5. Cable shall be Optical Cable BX series or approved equal.

2.2 PATCH CABLES

A. Flexible jumpers and patch cords utilized to extend optic signals from the LCT to the fiber optic transceivers and equipment. Cables shall be cut to length and factory terminated utilizing terminations compatible with the specified equipment. Cable shall be simplex or duplex zipcord type as required and shall include a high-performance tight-buffer coating on each optical fiber. Cable jacket shall be a flame-retardant flexible PVC that is OFNR rated and color coded per TIA-598-A.

B. Patch cables shall conform to the following specifications as a minimum:

1. Attenuation: 0.2 dB typical
2. Bandwidth:

a. 160 MHz/km @ 850 nm
b. 500 MHz/km @ 1300 nm

3. Cladding Diameter: 125 microns
4. Core Diameter: 62.5 microns
5. Fiber Type: Multi-mode
6. Insertion Loss: 0.3 dB typical, 0.5 dB max
7. Minimum Bend Radius: 5 cm

2.3 MISCELLANEOUS

A. Connectors shall be "ST" type with ceramic ferrules. Connector characteristics shall be compatible with cable characteristics listed in this section.

B. Light Cable Terminals (LCT) shall be configured for termination of fiber optic cable with the use of bulk head "ST" terminations. The main equipment room LCT shall be 19 inch rack mounted. In the remote equipment rooms, the LCT's shall be either wall mounted and equipped with a lock keyed like the SCC cabinets, or rack mounted in the SCC cabinets. Each LCT's shall be equipped for the intended cable quantities.

C. All fiber optic cable located in the exterior ductbank shall be installed in innerduct. Innerduct shall be Pyramid polyethylene Innerduct, SDR-11 series as manufactured by Pyramid, Endot, or another product approved by the Contracting Officer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All fiber optic cable shall be inspected prior to installation.

B. All cable shall be factory tested on a reel basis for each cable supplied to the Government.

1. The attenuation in dB/km units shall be recorded for each fiber. Tests shall be conducted at 850 nm and 1300 nm for multimode fiber and at 1310 nm and 1550 nm for single-mode fiber.
2. Bandwidth shall be recorded for each multi-mode fiber.

C. Cable shall be installed in accordance with the fiber optic TIA/EIA 568-B standards and with the manufacturer's recommended practices for field installation.

D. Patch cords shall be installed as shown on the drawings to interconnect fibers at the main LCT.

E. Each LCT port that is used to terminate a strand of fiber shall be labeled with a nomenclature that indicates the location from which the fiber strand originated. The nomenclature shall include the originating LCT name, as indicated in the Tables, and port number where the strand originated. Where fusion splices are required as indicated in the Contract Documents they shall not be included in the nomenclature scheme.

F. At the fiber cable bundle entrance of each LCT, the cable sheath shall be labeled with a nomenclature that indicates the fiber cable bundle originating SCC. The nomenclature shall indicate the name of the originating SCC and the number of fiber strands included in the fiber cable bundle.

G. At the fiber cable bundle entrance of each LCT, the cable sheath shall be labeled with a nomenclature indicating intended use. Nomenclature shall be from the Legend of the Fiber Optic Cable Fiber Assignment table. Examples of such nomenclature would be: Sentry LAN, Commissary LAN, etc.

3.2 COMPLETION

A. General: Upon completion of the work, remove excess debris, materials, equipment, apparatus, tools and the like and leave the premises clean, neat and orderly.

B. Testing: The completed system shall be tested by the Contractor prior to the acceptance test.

1. Each installed fiber cable, including the cable for the perimeter system, shall be tested for power through loss to reflect the following:
2. Each installed fiber cable shall be tested for power through loss to reflect the following:

a. Total end-to-end loss including connectors.
b. All tests shall be based at 850 nm and 1300 nm for multimode fiber and at 1310 nm and 1550 nm for single-mode fiber.

1) The horizontal fiber optic cable installed between the equipment closet and the workstation may be tested at a single wavelength.

c. End-to-end loss shall be measured from bulkhead-to-bulkhead to include cable splice jumper and connector losses. Loss for the multi-mode cables shall not exceed 3.5 dB/km at 850 nm and 1.5 dB/km at 1300nm. Loss for the single-mode cables shall not exceed 0.5 dB/km at 1310 nm and 0.5 dB/km at 1550 nm. Cable loss measurements shall be made in conformance with the fiber optic TIA/EIA 568-B standards and with the cable manufacturer's recommendations. Measurements shall be recorded on a per cable basis with loss measured for each strand.

C. Upon completion of the work, remove excess debris, materials, equipment, apparatus, tools and the like and leave the premises clean, neat and orderly.

END OF SECTION

SECTION 31 23 03
FOOTING PAD PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. The section applies to earth-supported building pads and other paving indicated on the drawings to receive “Building Pad Preparation”.
2. The section includes materials, labor and equipment required for complete installation of building pad including but not limited to: excavation, scarification and re-compaction of soils, moisturizing of soil, engineered fill material, lime and water injection, backfilling and compaction of soil, and installation of vapor retarder under slabs.
3. Testing for moisture content of soils, plasticity index of engineered fill, and compaction.

B. Section excludes – see other sections for:

1. Clearing and grubbing of site
2. Mass excavation and rough grading
3. Final grading of site
4. Laboratory testing and inspection

1.2 REFERENCES

A. American Society for Testing and Materials:

1. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
2. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
3. ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
4. ASTM D 2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
5. ASTM D 2488 - Standard Practice of Description and Identification of Soils (Visual-Manual Procedure).
6. ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Method (Shallow Depth).
7. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
8. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.3 SYSTEM DESCRIPTION

A. Footing pad preparation shall be as described in the Project Geotechnical Report, utilizing the following method(s):

1. Engineered Fill
   a. Excavate existing soils to provide minimum depth of engineered fill material.
   b. Place engineered fill in thin lifts and compact to footing bearing elevation.

2. Reconditioning of Existing Soil
   a. Excavation existing soil to required depth and stockpile on site.
   b. Remove debris and unsuitable material from stockpile.
   c. Test remaining soil for compliance with Engineered fill requirements.
   d. Add moisture to soil, replace in thin lifts and compact to footing bearing elevation.

B. Recommendations and specifications of the Project Geotechnical Report are based on soil borings taken at discreet locations. No representation is made or implied regarding continuity of conditions between borings. Additional soil borings may be made at Contractor's expense and option to verify subsoil conditions.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Contractor performing footing-pad preparation work shall have at least three years' collective experience with the specific method of preparation required, and under similar circumstances.
2. Upon request, demonstrate to the satisfaction of the Architect the dependability of the systems, materials and techniques to be used by experience, example or test.

1.5 PROJECT AND SITE CONDITIONS

A. Existing conditions: Contractor is responsible for locating and protecting existing underground utilities and building foundations.

B. Contractor shall inspect the site for conditions that may adversely affect installation of required building pads and report to the Architect before commencing work.

C. Contractor shall be thoroughly familiar with the Project Geotechnical Report.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate installation of footing pads with excavation, installation and removal of utilities and other site-related activities.

1.7 SUBMITTALS

A. Samples

1. Submit samples of engineered fill materials in sufficient quantity for laboratory testing

B. Testing and Inspection reports

1. Submit copies of required laboratory reports for compaction, moisture content, and soil characteristics.

PART 2 - PRODUCTS

2.1 ENGINEERED FILL MATERIALS

A. In accordance with the Project Geotechnical Report, the following fill types with stated characteristics may be used as engineered fill materials. Contractor shall select one type of engineered fill for use project-wide:

2. Lean Clay
   a. USCS Classification = CL

b. Liquid Limit less than 45%
c. Plasticity Index less than 25%
d. Existing soil matching these requirements may be used as engineered fill.

3. Well Graded Granular Fill
a. USCS Classification = GW (see below), SC, SW, SM
b. GW classification based on being similar to crushed limestone aggregate, limestone screenings, or granular material such as well-graded gravel or crushed stone.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify and identify required lines, levels, contours and benchmark elevations.

B. Locate and identify underground utilities.

C. Notify Owner of unexpected subsurface conditions.

D. Verify that excavations are in proper condition before placing fill material.

1. Subgrade conditions shall be thoroughly evaluated by a capable 3rd party testing agency.

3.2 PREPARATION

A. Protection:

1. Protect benchmarks and existing structures to remain from excavation equipment and vehicular traffic.
2. Protect plant life, lawns, rock outcroppings, and other features remaining as a portion of final landscaping.
3. Protect excavations from rain and from drying out when construction has been delayed, cave-ins or loose soil from falling into excavations, and from freezing.
4. Provide barricades, warning signs, lights, and other items at open excavations to comply with governmental regulations.
5. Maintain and protect above and below grade utilities to remain.

B. Surface Preparation:

1. Notify utility companies to remove and relocate existing utilities.
2. Correct irregularities in substrate gradient and elevation by scarifying, reshaping and re-compacting.
3. Compact excavation surface material to density requirement for backfill materials.
4. Where required by the capable 3rd party testing agency, scarify and re-compact the excavation surface.

3.3 EARTHWORK

A. Excavation

1. Excavate to required subgrade elevation, which is a minimum two-feet below bottom of footing.

B. Stockpiling

1. Stockpile excavated material on site for use as general site fill.
    a. Do not pile soil within the drip line of trees to remain.
    b. Locate and retain stockpile away from the edges of excavations.
    c. Protect stockpile from erosion.
    d. Dispose of excess excavated materials and materials not suitable for reuse off site premises.

C. Excavation stability

1. Slope sides of excavation to comply with governmental regulations.
    a. Maintain sides and slopes of excavation in safe condition.

D. Proof Rolling

1. Proof roll excavated subgrade using a loaded tandem-axle dump truck.

E. Backfilling

1. Before backfilling, check and prepare subgrade:
    a. Remove ice, snow or standing water.
    b. Remove debris and trash.
    c. Verify proper subgrade elevation(s).
    d. Scarify and re-compact soft spots and loose surface materials.
    e. 3rd party testing agency shall inspect subgrade.

2. Backfill under slabs with required engineered fill materials to subslab elevation.
   a. Backfill in thin lifts, moisturize and compact material as follows:
      1) Cohesive Material (Lean Clay).
         a) 9-inch or less loose thickness if compacted with heavy, self-propelled compaction equipment.
         b) 4 to 6-inches loose thickness if compacted with hand-guided equipment.
         c) Compact to at least 98% of material's standard proctor maximum dry density determined in accordance with ASTM D 698.
         d) Moisture content within the range of 1% below to 2% above the optimum moisture content value based on standard proctor test at time of placement and compaction.
      2) Granular Material (Gravel or Crushed Limestone).
         a) 9-inch or less loose thickness if compacted with heavy, self-propelled compaction equipment.
         b) 4 to 6-inches loose thickness if compacted with hand-guided equipment.
         c) Compact to at least 100% of material's maximum dry density determined in accordance with ASTM D 1557.
         d) Moisture levels shall be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.
   b. Do not attempt to place backfill during rain, snow, or sleet.
   c. Do not place fill material on frozen ground.

F. Moisture control and protection

1. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to required density.
2. Protect and maintain moisture content of subgrade until placement of slabs.

3.4 FIELD QUALITY CONTROL

A. Inspection Services: an independent testing agency shall perform the following inspection services:

1. Inspect stockpiles of excavated material for reuse.
2. Inspect engineered backfill material for suitability.
3. Observe backfilling and compacting procedures.
4. Observe proof rolling process.

B. Laboratory Testing

1. Test each lift of backfill for moisture content and compaction before subsequent lifts are placed.
   a. Perform field density tests in accordance with ASTM D698, D3017, D2922 or D4318
   b. Perform one density test for each 3,000 square feet of surface area, or at least 2 tests per unit of work.
   c. Perform additional tests until required density and moisture content are achieved.

2. Test engineered fill material for soil characteristics (moisture content, plasticity index).
3. Determine subgrade modulus, where required.

END OF SECTION